2019 California Forest Pest Conditions

A publication of the
California Forest Pest Council

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2019 Aerial Detection Survey Summary
41 million acres surveyed
2.2 million acres with tree mortality
15.1 million dead trees

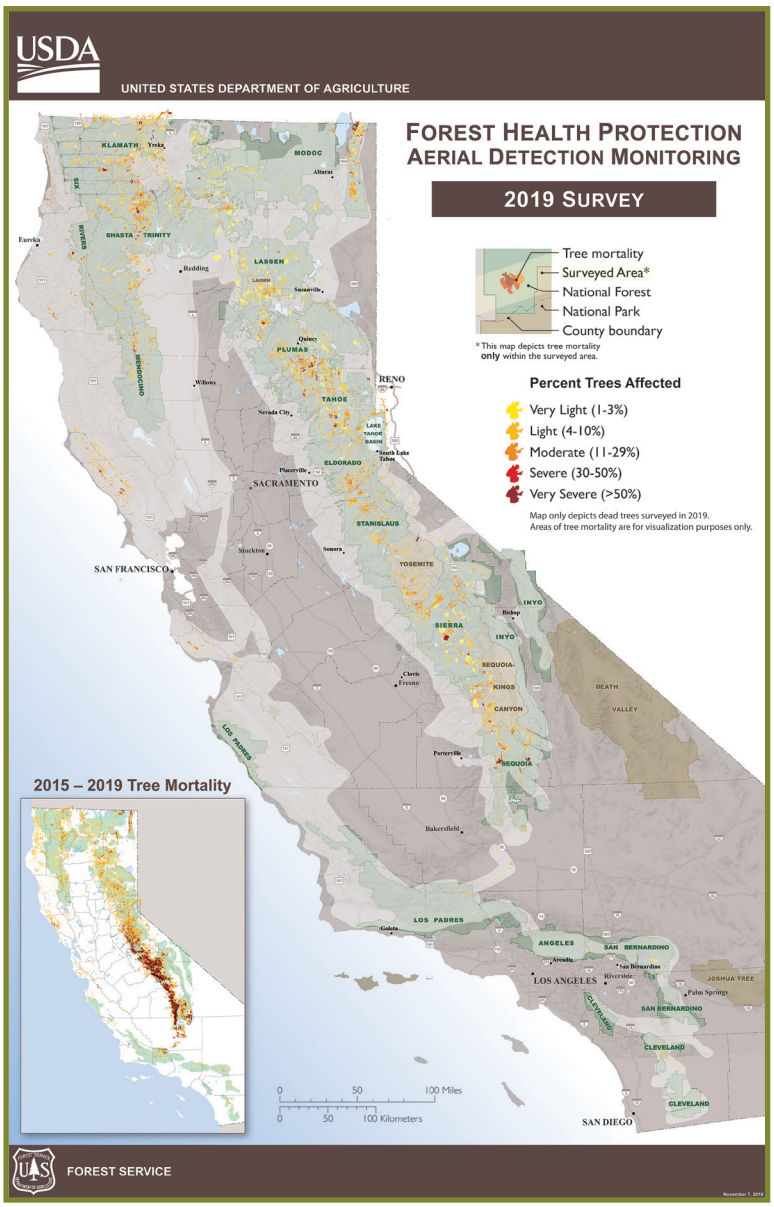
The USDA Forest Service, Pacific Southwest Region, State and Private Forestry staff conducts annual aerial surveys throughout forested areas of California to detect recent tree mortality, defoliation, and other damage. Surveys are flown in a small, fixed-wing aircraft on a 4-5 mile grid pattern with 2 observers recording from opposite sides of the plane. Most National Forests and Parks in California are surveyed, along with other federal, state, and private forested lands. Surveys were flown from June through August.

For the 2019 flight season, approximately 41 million acres were surveyed. Elevated levels of tree mortality were recorded on approximately 2.2 million acres, totaling an estimated 15.1 million dead trees, mostly in fir, ponderosa and Jeffrey pine, and tanoak. Most of the mortality can likely be attributed to the lingering effects of the recent exceptional drought and subsequent successful bark and engraver beetle attacks that have now resulted in ~163 million dead trees since 2010.

Acres reported below may be noted in more than one bullet, as multiple damaging agents often occur in the same location. Additionally, not all host trees in any given acre were killed or damaged. The numbers of acres and trees below are rounded to the nearest 1,000, as appropriate.

Bark Beetles and Wood Borers

- California red fir (*Abies magnifica*) and white fir (*Abies concolor*) comprised over 82% of the tree mortality recorded in 2019. Approximately 12.4 million dead firs were recorded across ~1.9 million acres, compared to ~14 million dead firs across ~1.4 million acres in 2018.
- Pine mortality attributed to western pine beetle (*Dendroctonus brevicomis*) decreased from 950,000 dead trees across 166,000 acres in 2018 to an estimated 793,000 dead trees across 124,000 acres in 2019.
- Pine mortality attributed to mountain pine beetle (*Dendroctonus ponderosae*) remained elevated with an estimated 500,000 dead trees across 50,000 acres in 2018 and ~552,000 dead trees across 57,000 acres in 2019.
- High elevation 5-needle pine (i.e. limber (*P. flexilis*), whitebark (*P. albicaulis*) and western white (*P. monticola*)) mortality increased to ~272,000 dead trees across 29,000 acres from approximately 242,000 dead trees across 18,000 acres in 2018. Mortality was particularly severe and widespread in higher elevations of the southern Sierra Nevada Range.



USFS Aerial Detection Survey, Tree Mortality, 2019.
Map by: M. Woods, USFS

High levels of top-kill and whole tree mortality of red fir west of Tobias Peak, Sequoia NF (Tulare County). Photo by: J. Moore, USFS

Ponderosa pine and white fir mortality southwest of Fresno Dome, Sierra NF (Madera County). Photo by: J. Moore, USFS

Ongoing oak mortality near Pine Mountain, Cleveland NF (San Diego County). Photo by: J. Moore, USFS

- Mortality from Jeffrey pine beetle (*Dendroctonus jeffreyi*) decreased to 67,000 acres and 179,000 dead trees, compared to 99,000 acres and 753,000 dead trees in 2018.
- Goldspotted oak borer (*Agrilus auroguttatus*)-related oak mortality, mostly in San Diego County, increased to ~11,000 acres affected and ~17,000 dead trees from ~3,700 acres and ~11,000 dead trees recorded in 2018.
- Mortality of an estimated 11,000 Jeffrey pines attributed to Ips engraver beetles was recorded on 3,000 acres in and around the northeast portions of the Mt. Pinos Ranger District, Los Padres National Forest.
- Douglas-fir mortality (not attributed to damage by bears) remained elevated in 2019 with an estimated 127,000 dead trees across 27,000 acres, compared to 107,000 dead trees across 32,000 acres in 2018.

Ongoing moderate tanoak mortality north of Blocksburg (Humboldt County). Photo by: J. Moore, USFS

Defoliation

- Severe defoliation of quaking aspen (*Populus tremuloides*), primarily attributed to Marssonina leaf blight (*Marssonina* spp.), was observed across 4,200 acres in eastern portions of the Sierra Nevada Range.
- Multiple agents were involved in defoliation of pinyon pine (*Pinus monophylla*) that was observed on approximately 37,000 acres in and around the Inyo National Forest. Approximately 9,000 acres of the defoliation was attributed to pinyon needle scale (*Matsucoccus acalyptus*) by ground survey.
- Severe defoliation of lodgepole pine (*Pinus contorta*) on approximately 12,000 acres in and around Yosemite National Park was attributed to lodgepole pine needleminer (*Coleotechnites milleri*).
- Severe defoliation of white fir attributed to sawfly (*Neodiprion abietis*) was detected in Sierra County, primarily on the Tahoe National Forest.
- Severe defoliation of Sitka spruce (*Picea sitchensis*) due to spruce aphid (*Elatobium abietinum*) was detected on approximately 1,250 acres along the north coast of California, particularly north of Crescent City near the Oregon border.

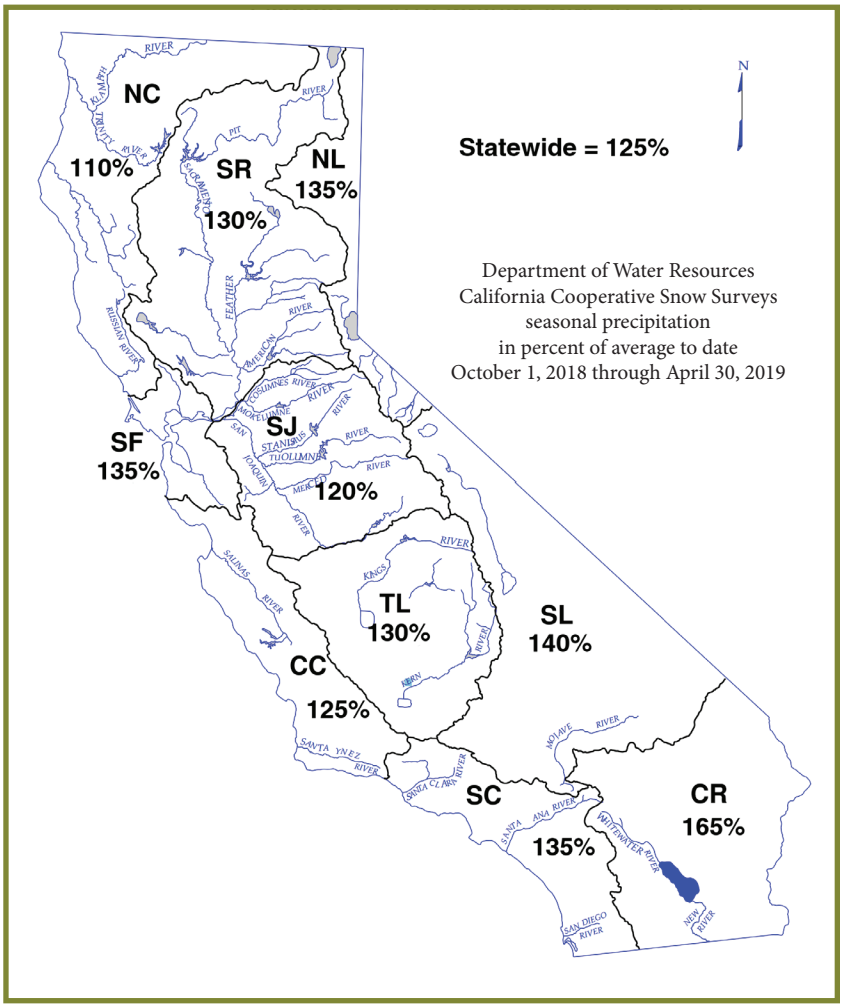
Diseases

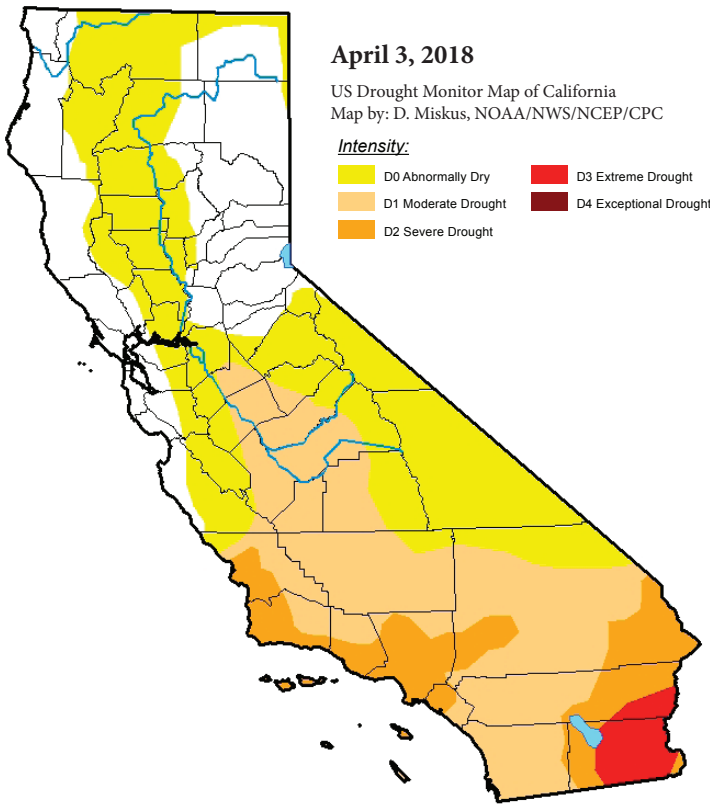
- Tanoak (*Notholithocarpus densiflorus*) mortality attributed to sudden oak death (*Phytophthora ramorum*) remained elevated with an estimated 885,000 dead oak trees across 92,000 acres in 2019, compared to ~1.6 million dead trees across 106,000 acres in 2018.

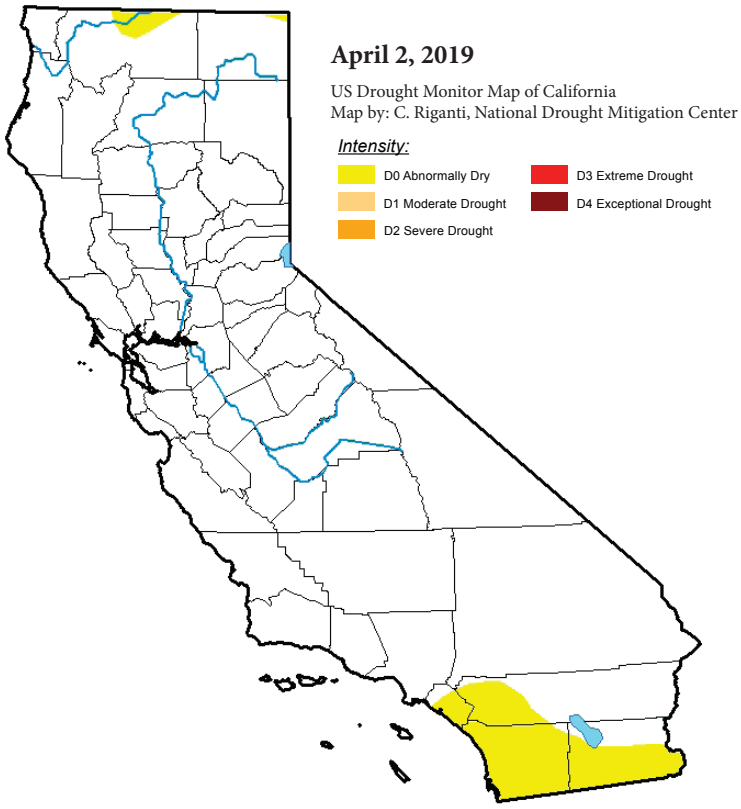
Lingering impacts from the 5-year drought, sudden oak death, and overstocked forests were the most significant factors affecting California forest health in 2019, with ~15.1 million dead trees mapped across 2.2 million acres (US Forest Service Aerial Detection Program). This is the third year in a row that tree mortality levels have declined statewide, down from a high of 54 million dead trees recorded or detected in 2016. Tree mortality remains elevated from usual background levels.

Statewide precipitation in precent of average to date from October 2018 - April 2019 was 125% of average, compared to 75% for the same time period in 2017-2018. Northern California forested area rainfall totals were 110 - 135% of average, and southern coastal areas were 135% of average (see map on right). The 2018-2019 water year (water year is from October 1 – September 30) was the 20th wettest on record (since January 1895) and the wettest since 2017. Most precipitation occurred in January and February 2019. February was the third-wettest February on record.

Statewide temperatures varied widely from historical averages (1895 - 2019). February was the coldest since 1949 (4.9°F below the February average), and May was also colder than average. August was the sixth-warmest (3.1°F above the August average), and April and January were also warmer than average. For 2019, the annual temperature across California was 1.0°F above average.





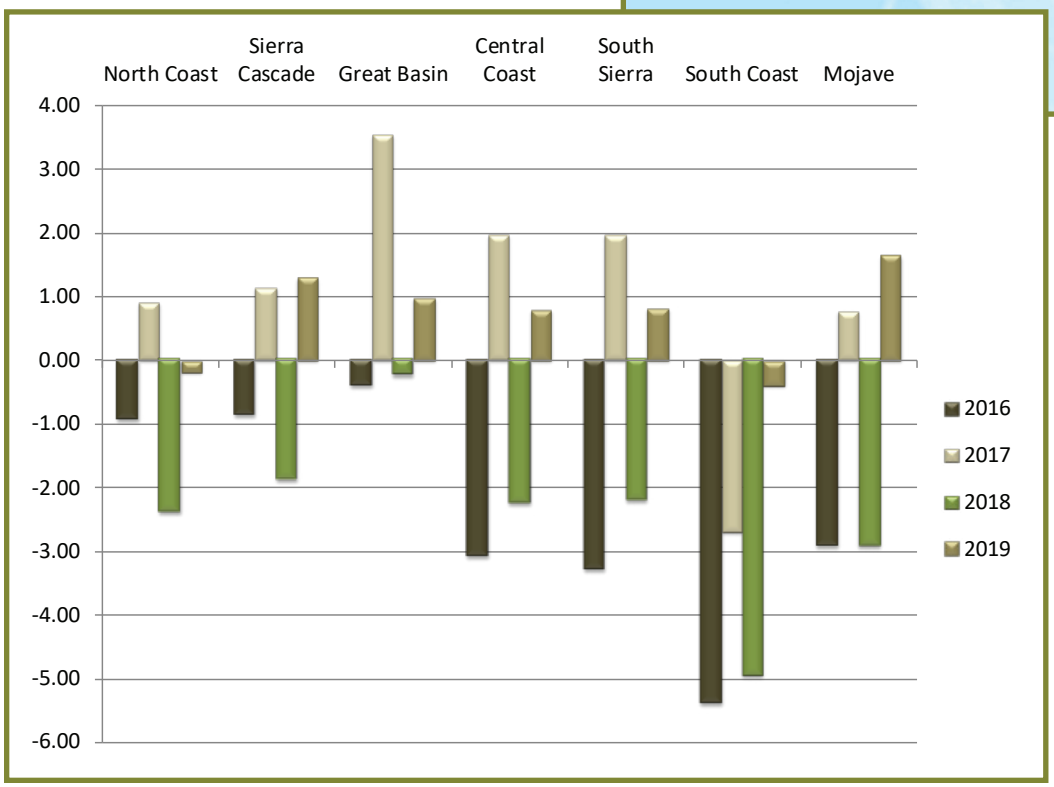


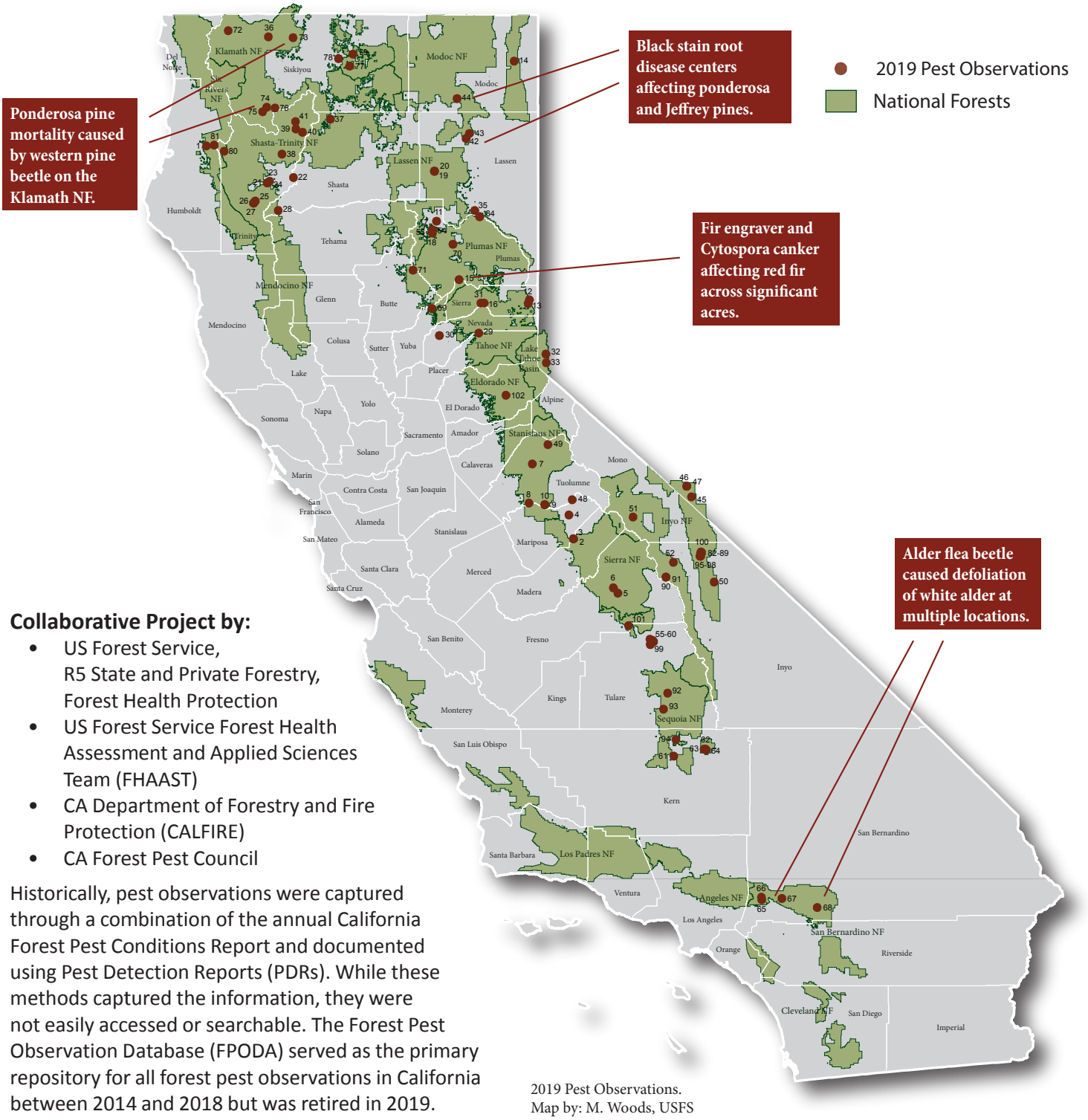
Palmer Drought Index

The Palmer Drought Severity Index (PDSI) is an indicator of drought and moisture excess, with negative values denoting degree of drought. In 2019, the yearly average PDSI values ranged from 1.66 in the Mojave (least dry zone) to -0.39 in the South Coast (driest zone) (see map). The South Coast was the only zone that did not observe some reprieve from drought in the 2019 water year, compared to the rest of the state (denoted by positive numbers).

Climate Divisions for the Palmer Drought Severity Index. Map by: M. Woods, USFS

Palmer Drought Severity Index (PDSI) for California, 2016 - 2019





2019 Pest Observations.
Map by: M. Woods, USFS

Collaborative Project by:

- US Forest Service, R5 State and Private Forestry, Forest Health Protection
- US Forest Service Forest Health Assessment and Applied Sciences Team (FHAAST)
- CA Department of Forestry and Fire Protection (CALFIRE)
- CA Forest Pest Council

Historically, pest observations were captured through a combination of the annual California Forest Pest Conditions Report and documented using Pest Detection Reports (PDRs). While these methods captured the information, they were not easily accessed or searchable. The Forest Pest Observation Database (FPODA) served as the primary repository for all forest pest observations in California between 2014 and 2018 but was retired in 2019.

A mobile pest detection data entry form was developed and released in 2018 and has been adopted across the Forest Health Proection Service Areas. Ground-based observations are located in a database on ArcGIS Online (AGOL). All records from FPODA will be migrated to the new database in 2020. A new AGOL web app is planned for users to access and query the database.

For 2019, all observations were submitted via the mobile data entry form. This map shows the locations of pest observations made by forest health professionals in 2019. The most frequently reported damage-causing agents were black stain root disease and maple decline. The most frequently reported host species were big leaf maple (*Acer macrophyllum*), singleleaf pinyon pine, and ponderosa pine. These reports supplement the Aerial Detection survey (see page 2).

Native Insects

Douglas-fir Beetle (*Dendroctonus pseudotsugae*)
Douglas-fir beetle galleries were observed on five windthrown Douglas-fir (*Psuedotsuga menziesii*) near Timber Cove (Sonoma County). The root systems of the five trees were colonized by *Phaeolus schweinitzii*. Galleries, boring dust, and entrance holes were observed on two large (>40 inches diameter at breast height [DBH]) windthrown Douglas-fir along the east branch of the South Fork Eel River (Humboldt County); *Phaeolus schweinitzii* fruiting bodies were observed near the attacked trees.

Fir Engraver (*Scolytus ventralis*)
In 2018 hot and dry weather conditions in Siskiyou County led to a continued increase in fir engraver beetle-caused mortality of white (*Abies concolor*) and red (*Abies magnifica*) fir into 2019. Scattered red fir mortality (~1 dead tree/acre) was observed on the Klamath National Forest near Ball Mountain (Siskiyou County). White fir mortality increased to 5-10 dead trees per acre around Castle Lake on the Shasta-Trinity National Forest (Siskiyou County). White fir mortality was observed on Herd Peak, Klamath National Forest (Siskiyou County) with several patches of 3-6 dead trees. The pattern of mortality resembled a Heterobasidion root disease (*Heterobasidion occidentale*) center, but no conks were seen.

Low to moderate levels of white fir and red fir mortality (~1 to 2 dead trees/acre) were found throughout northeastern California despite the return to normal to above-normal precipitation since 2016. The highest levels of red fir mortality were found on the Plumas National Forest near Pilot Peak (Plumas County) associated with western dwarf mistletoe (*Arceuthobium abietinum*) and Cytospora canker (*Cytospora abietis*) infections. Field observations revealed that many trees had sustained sublethal attacks during the recent drought from both fir engraver and woodboring beetles (Families: Buprestidae and Cerambycidae) and were only now succumbing to these attacks. Active fir engraver infestations were noted on three white firs (>24 inches DBH) with Heterobasidion root disease in 2019 on the Lassen National Forest near Domingo Springs (Plumas County).

White and red fir mortality has increased since 2016 at high elevations (often >7,000 ft) in the southern Sierra Nevada Range due to fir engraver beetles. Sequoia-Kings Canyon National Park (Tulare County) had ~2 dead trees/acre in 2019. Red firs in Siretta Meadow on the Sequoia National Forest (Kern County) had severe branch flagging and appeared in very poor condition but were still alive. Overall, true fir stands along Sherman Pass (Kern County) appeared distressed with an accumulation of recent and older dead trees, old top kill, and widespread branch flagging.

In Yosemite National Park near Porcupine Campground (Mariposa County), fir engraver activity was highly visible on exposed slopes, and dead trees (~1-2 dead trees/acre) ranged

Fir engraver beetle-caused white fir mortality near Castle Lake, Shasta-Trinity NF.
Photo by: C. Snyder, USFS

Ongoing red fir mortality near Wolverton Meadows, Sequoia-Kings Canyon NP.
Photo by: B. Bulaon, USFS

Red fir mortality along Siretta Forest Road, Kernville RD, Sequoia NF.
Photo by: B. Bulaon, USFS

in size from 6-15 inches DBH. The Stanislaus National Forest (Tuolumne County) exhibited red fir mortality (~3 dead trees/acre) between 7,000 and 9,000 ft in elevation. Branch flagging was evident across all age classes. In the Emigrant Wilderness above 9,000 ft in elevation, trees appeared much healthier but with occasional yellow broom rust (*Melampsorella caryophyllacearum*).

Fir engraver beetles were active around Mammoth Lakes and Inyo Craters (Mono County). Mortality (~2 dead trees/acre) occurred in mature overstory red firs that faded and declined from the top down, although some tops were killed prior to 2017.

Small, understory white fir trees impacted by fir engraver and root disease surrounding Jenks Lake, San Bernardino NF. Photo by: S. Hishinuma, USFS

Elevated levels of white fir mortality continued this year on the San Bernardino National Forest (San Bernardino County) near Barton Flats, Jenks Lake, and along the Santa Ana River corridor. Approximately 50 acres of understory white fir mortality occurred near Jenks Lake due to fir engraver beetles and Heterobasidion root disease. Mortality was ~5 dead trees/acre with a greater intensity near the lake (~ 10 dead trees/acre). Near the Santa Ana River, understory white fir mortality occurred over a 60-acre area with ~5-7 dead trees/acre and smaller groups of higher mortality (~15 dead trees/acre).

Understory white fir mortality caused by fir engraver and root disease near the headwaters of the Santa Ana River near Barton Flats, San Bernardino NF. Photo by: S. Hishinuma, USFS

Ips Engraver Beetle *(Ips* spp.)
Low levels of pinyon pine (*Pinus monophylla*) mortality (~1 dead tree/acre) caused by *Ips confusus* were observed in the Kiavah Wilderness on Scodies Mountain, Sequoia National Forest (Kern County).

Small diameter lodgepole pine around the visitor center in Sequoia-Kings Canyon National Park (Tulare County) were infested with engraver beetles (*Pityogenes knechtel*). Nearly all trees surrounding the visitor center were killed primarily by *P. knechtel*. Some *Ips pini* galleries were noted, but very few. Trees killed last year were removed, but three trees with active *P. knechtel* remained.

Mountain Pine Beetle (*Dendroctonus ponderosae*)
Mountain pine beetle caused scattered lodgepole pine (*Pinus contorta*) mortality (~1 dead tree/acre) near Deer Mountain Snowmobile Park, Klamath National Forest (Siskiyou County). Scattered lodgepole pine mortality was also observed (~1 dead tree/acre) near the lava flows on the eastern border of the Shasta-Trinity National Forest (Shasta County) in stands that were historically aspen (*Populus tremuloides*) meadows.

Mountain pine beetle remained active in lodgepole pine at the Chain-of-Lakes in Mammoth Lake, Inyo Craters (Mono County),

Mountain pine beetle in lodgepole pine near Deer Mountain Snowmobile Park, Klamath NF. Photo by: C. Snyder, USFS

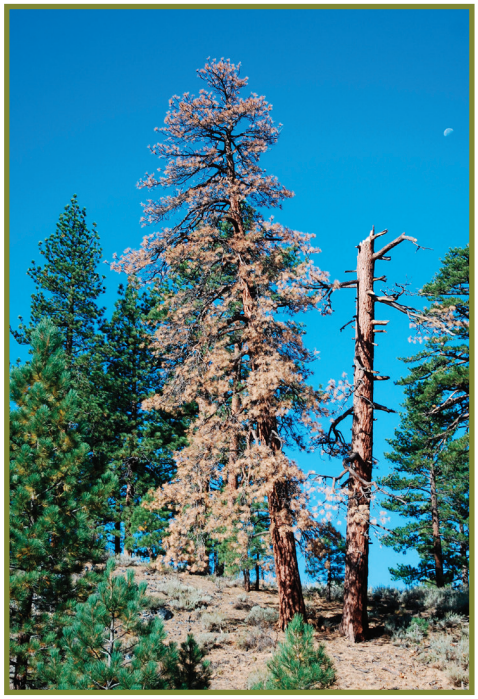
May Lake (Yosemite National Park, Mariposa County), Lodgepole Visitor Center and Campground, and Hockett Meadows (Sequoia-Kings Canyon National Park (Tulare County). The amount of lodgepole pine mortality was low at all sites (~2-3 dead trees/acre) and around the visitor center has slowed since 2016 (2-5 dead trees/acre).

Moderate to severe western white pine (*Pinus monticola*) mortality (~25 dead trees/acre) was observed at Bald Mountain in the north Warner Mountains, Modoc National Forest (Modoc County) and Babbitt Peak in the Bald Mountain Range, Tahoe and Humboldt-Toiyabe National Forests (Sierra County). At the Babbitt Peak site, mountain pine beetle killed trees with and without white pine blister rust (*Cronartuim ribicola*) infections. Trees with rust cankers showed top kill due to beetle attacks above the cankers.

Western white pine mortality caused by mountain pine beetle, associated with white pine blister rust, Tahoe NF. Photo by: D. Cluck, USFS

Jeffrey Pine Beetle
(*Dendroctonus jeffreyi*)

Jeffrey pine beetle attacked small diameter Jeffrey pine (*Pinus jeffreyi*) (<12 inches DBH) in groups of 5-20 trees outside of Mammoth Lakes (Mono County). Sites were heavily stocked, and infested trees were suppressed or stressed. Attacked single mature trees growing in open stands exhibited poor crown conditions.



Jeffrey pine mortality caused by Jeffrey pine beetle, Mammoth RD, Inyo NF. Photo by: B. Bulaon, USFS

Jeffrey pine beetle galleries found in a 15-inch tree, Inyo NF. Photo by: B. Bulaon, USFS

Red Turpentine Beetle
(*Dendroctonus valens*)

In the southeastern Sierra Nevada Range, red turpentine beetles attacked pines that were also under attack from mountain or Jeffrey pine beetles. Red turpentine beetles were also observed on pinyon trees (*Pinus monophylla*) that were infested by pinyon pitch mass borers (*Dioryctria ponderosae*) (see "Other Highlights", below) at a trailhead into the Boundary Peak Wilderness (Mono County). Trees appeared highly stressed, given the equal numbers of red turpentine beetle and pinyon pitch mass borer attacks. No tree mortality was observed. Ten heavily fire-scorched large sugar pines (*Pinus lambertiana*) that survived the Railroad Fire (Sierra National Forest, Madera County) were attacked by red turpentine beetles, but no tree mortality was observed.

Western Pine Beetle (*Dendroctonus brevicomis*)

Western pine beetle-caused mortality appeared to be above background levels throughout most of northern California. Increases were detected primarily at low elevation (<4,000 ft), dry sites. Several groups of 5 to 20 ponderosa pines (*Pinus ponderosa*) were killed along Hirz Bay of Shasta Lake, Shasta-Trinity National Forest (Shasta County). The extended drought of 2012-2016 weakened many of the pines, which were not able to recover fully in 2017 when precipitation levels normalized. Similar levels of ponderosa pine mortality were observed along Walker Ridge and Humbug Ridge on the Klamath National Forest (Siskiyou County).

Large grouping of western pine beetle-associated mortality in mature ponderosa pines, Lower Pines Campground, Yosemite NP. Photo by: B. Bulaon, USFS

Ponderosa pines killed by western pine beetle, Sentinel Beach Picnic Area, Yosemite NP. Photo by: B. Bulaon, USFS

In the south Sierra Nevada Range, western pine beetle remained active in areas that experienced severe mortality during the 2012-2016 drought. Several groups of ponderosa pines died in Lower Pines Campground near the Merced River in Yosemite Valley, Yosemite National Park (Mariposa County). The largest group included 35 dead trees. There were also two groups of 5-10 trees, ~30 inches DBH. Two smaller groups (5-10 trees each) of dead trees of the same diameter were found in the campground. Multiple stumps were found, as western pine beetle has been active in the area previously and dead trees had been removed.

Ponderosa pine mortality was also observed in other areas near or in Yosemite Valley. Between Cathedral Picnic Area and Sentinel Campground, two groups of four ~23-inch DBH dead ponderosa pines were observed as a result of western pine beetle. Beetles most likely became active in the area after a prescribed burn weakened the trees. Sixteen ponderosa pines were killed along the Merced River, Yellow Pines Volunteer Campground.

Boring dust of ambrosia beetles (*Platypus* spp.) on a fading white fir, Bass Lake RD, Sierra NF. Photo by: B. Bulaon, USFS

Other Highlights

Ambrosia Beetles (*Platypus* spp.)

Platypus species were detected at the base of recently killed large-diameter true firs (*Abies* spp.) across the southern Sierra Nevada Range. Fir engraver beetles were observed attacking the main trunks prior to the *Platypus* attacks on the Sierra National Forest, Bass Lake Ranger District (Madera County). *Platypus* boring dust completely covered the lower trunks, and many live beetles were observed.

Pinyon Pitch Mass Borer (*Dioryctria ponderosae*)

Large limb dieback and top-kill of pinyon (*Pinus monophylla*) by pinyon pitch mass borer (PPMB) were observed near a trailhead to Boundary Peak Wilderness (Mono County). Saplings (< 5 ft tall) were primarily targeted at this site but were not directly killed. One in every ten trees had branches with large new and old pitch masses. The infestation appears to be chronic.

Branch flagging associated with pinyon pitch mass borer infestation. Boundary Peak Wilderness, Inyo NF. Photo by: B. Bulaon, USFS

Unknown Bark Beetle

Scattered Paiute cypress (*Hesperocyparis nevadensis*) mortality (~1 dead tree/acre) was observed in Bodfish Grove, Sequoia National Forest (Kern County). Trees showed signs of bark beetle activity (i.e., galleries under the bark) on the main trunk and branches. The same gallery pattern was found on several other older dead trees in the grove. No samples were collected, and the beetle species was not identified.

White Fir Sawfly (*Neodiprion abietis*)

White fir sawfly-caused defoliation of white fir (*Abies concolor*) was observed on the Plumas National Forest (Plumas County) near Haskell Peak across several hundred acres. Trees of all size classes were defoliated with higher defoliation levels in the smaller trees.

Flatheaded fir borer continued to kill Douglas-fir near the Salmon River, Klamath NF. Photo by: C. Snyder, USFS

Fall Webworm (*Hyphantria cunea*)

Fall webworm-caused defoliation of Pacific madrone (*Arbutus menziesii*) was observed on the Plumas National Forest (Yuba County) near the towns of Challenge and Clipper Mills (~1,000 acres observed at ~2 dead trees/acre). Trees of all size classes suffered near-complete defoliation early in the summer, but new foliage was apparent throughout the crowns of most trees by early October.

Flatheaded Fir Borer (*Phaenops drummondi*)

Scattered single trees and large groups of Douglas-fir (*Pseudotsuga menziesii*) mortality continued to occur throughout northern California due to the flatheaded fir borer. Large groups of older Douglas-fir mortality along the South Fork Salmon River between Trail Creek and Shadow Creek (Siskiyou County) had ~1-5 new dead trees/group. New mortality also occurred on private land along the North Fork Salmon River near Sawyers Bar (~1-5 dead trees/acre). Dead trees appeared to have been repeatedly attacked by borers since the recent drought.

In northwestern California, flatheaded fir borer caused mortality of single trees and small groups of mature Douglas-fir from Sonoma/Napa Counties up through Del Norte/Siskiyou Counties. This insect is attracted to trees growing on stressful microsites - often sites that are well-suited for true oaks (*Quercus* spp.). Dead trees often remain standing in these dry areas for many years.

Twenty to forty mature dead Douglas-firs (*Pseudotsuga menziesii*) were observed on the fringes of an open oak woodland along the east branch of the South Fork Eel River, Humboldt County. A *Pityokteines* sp. was also observed at this location in recently killed Douglas-firs. This is a secondary bark beetle that normally attacks only branches, but adults were recovered from beneath the bark of the main trunks of these Douglas-firs.

Engravers and Root-Feeding Bark Beetles (*Pseudips* sp., *Ips* sp., and *Hylurgops porosus*)

Pseudips mexicanus, *Ips plastographus*, and *Hylurgops porosus* adults and larvae were observed in individual windthrown and cut bishop (*Pinus muricata*) and lodgepole pines (*Pinus contorta*) in several locations on the north coast, including the California State Parks Headquarters office near Mendocino (Mendocino County), MacKerricher State Park north of Fort Bragg (Mendocino County), Fisk Mill Cove in Salt Point State Park north of Fort Ross (Sonoma County), and along Samoa Boulevard in Arcata (Humboldt County). *H. porosus* was also observed on a recently cut Sitka spruce (*Picea sitchensis*) trunk in Arcata (Humboldt County).

Sequoia Pitch Moth (*Synanthedon sequoiae*)

Though not considered an important forest pest, Sequoia pitch moth has had an impact in ponderosa pine plantations on the eastern edge of the Shasta-Trinity NF (Siskiyou County) northeast of Bartle. Sapsucker feeding on several of the plantation trees (~2 trees per acre) produced sap flow that attracted the moths, which resulted in copious amounts of resin forming globular masses on the bark. Larvae caused very little injury to cambium or wood. Sequoia pitch moth damage doesn't usually cause girdling, and it rarely kills trees.

Sequoia pitch moth resin masses on ponderosa pine on the eastern edge of Shasta-Trinity NF. Photo by: C. Snyder, USFS

Thinning branches primarily in the upper crown with current infestations by pinyon needle scale, Inyo NF. Photo by: B. Bulaon, USFS

Pinyon needle scale egg masses discovered at the base of an infested pinyon pine, Inyo Mountains, Inyo NF. Photo by: B. Bulaon, USFS

Pinyon Needle Scale (*Matsucoccus acalyptus*)
Aerial surveys detected many acres of pinyon pine (*Pinus monophylla*) defoliation in Inyo County. Subsequent ground checks detected over 100 acres of defoliation by pinyon needle scale near the intersection of Highway 168 and White Mountain Rd. The defoliation was most intense on small trees less than 10 ft tall. Many trees had thin crowns and dead branches and tops. Most small diameter (<5 inches DBH) trees retained their current year needles but had lost all past years needles. A few scale cases were observed on the remaining foliage, and there were no pinyon *Ips* attacks. No tree mortality was observed. Pinyon needle scale was first detected in this area in 2008, but no mortality has occurred due to the infestation.

Pinyon needle scale-defoliated pinyon pines were also detected north of Death Valley Road (Inyo Mountains, Inyo County). Bulky cotton-like egg masses were observed at the base of several trees. Large trees (>15 inches DBH) in this area were heavily impacted.

Introduced Insects (Naturalized)

Balsam Woolly Adelgid (*Adelges piceae*)
On the north coast, balsam woolly adelgid (BWA) did not affect any new areas of grand fir (*Abies grandis*), but tree deterioration and mortality intensified in existing infestation areas. Grand fir stands infested with BWA show a slow decline and are affected long-term by other insect and disease agents such as fir engravers and Armillaria and Heterobasidion root diseases. These agents together cause increasing canopy transparency, lichen proliferation, and a prevalence of gray crowns over red ones. BWA-related damage increased in three areas where it had been observed prior to 2019: Fortuna (Humboldt County) had two 40-60 acre damaged stands; Westport (northern Mendocino County) had several 10-20 acre stands with damage visible from Highway 1; and Point Arena (southern Mendocino County), where increasing damage was visible along a 5-10 mile strip on Highway 1 between Point Arena and Manchester.

White Satin Moth (*Leucoma salicis*)
Aspen (*Populus tremuloides*) defoliation was observed in the north Warner Mountains, Modoc National Forest (Modoc County) during aerial detection survey flights. Ground checks are pending to identify the causal agent. Satin moth activity had previously been noted in this area.

Green Spruce Aphid (*Elatobium abietinum*)
Severe Sitka spruce (*Picea sitchensis*) defoliation was caused by green spruce aphid in Del Norte and Humboldt Counties. Warm

Examples of feeding injury caused by white satin moth.
Photo by: D. Cluck, USFS

Examples of aspen deloliation caused by white satin moth.
Photo by: D. Cluck, USFS

winters are known to encourage spruce aphid outbreaks, and similar defoliation was noted in coastal Oregon during 2019. Several large areas of defoliation were observed from Highway 101 and by aerial survey at the California-Oregon border (Del Norte County), along Freshwater, Stone, and Big Lagoons (Humboldt County), near McKinleyville and Arcata (Humboldt County), and between Eureka and Fortuna (Humboldt County). Defoliation was typically concentrated low in the tree crowns. Some trees were 80-90% defoliated, with only a few feet of foliage remaining at the top of the crown. By October, foliage recovery was observed on some heavily impacted trees.

Sitka spruce recovering from spruce aphid defoliation near Lake Earl, Del Norte County.
Photo by: C. Lee, CALFIRE

Sitka spruce defoliation caused by spruce aphid near Loleta, Humboldt County. Photo by: C. Lee, CALFIRE

Invasive Insects

Asian Gypsy Moth (*Lymantria dispar asiatica*, a subspecies of European Gypsy Moth, *Lymantria dispar dispar*)
No Asian gypsy moths (AGM) were detected in California in 2019.

European Gypsy Moth (*Lymantria dispar*)
One North American/European mitotype male was trapped in August 2019 in Yuba County. Delimitation traps were placed around the find and will also be placed out next year. There were also twelve instances of various life stages being detected at the California Department of Food and Agriculture border stations on articles entering the state.

Goldspotted Oak Borer (*Agrilus auroguttatus*)
Los Angeles County
Goldspotted oak borer (GSOB) continued to cause coast live oak (*Quercus agrifolia*) injury and mortality on private land in Green Valley and on a small private inholding within the Angeles National Forest (Los Angeles County). Los Angeles County Fire Department – Forestry Division conducted extensive education and outreach to residents and has begun an aggressive infested tree removal program. A total of 6,653 coast live oak trees have been inspected in Green Valley, and 31% (2,031) of those were infested with GSOB. In late 2019, 669 oaks infested with GSOB remained and were marked for removal.

In July 2019, a new infestation of GSOB 4 miles from the current infestation in Los Angeles County was found on California black oak (*Quercus kelloggii*) in Bouquet Canyon. This is within the current GSOB Zone of Infestation. This infestation was most likely initiated by borers emerging from infested firewood brought into this location.

Orange County
Ten GSOB-infested trees were discovered for the first time in Trabuco Canyon on land managed by the Orange County Transportation Authority. This infestation is near the western foothills of the Trabuco Ranger District, Cleveland National Forest - at least 10 miles from the other known infestations and outside of the GSOB Zone of Infestation. One heavily infested tree was removed by the Orange County Fire Authority. The Emerging Tree Pests of Orange County group is working on a GSOB response plan for the area.

From the fall of 2018 through the spring of 2019, Irvine Ranch Conservancy staff surveyed 769 coast live oak trees in Upper Weir Canyon on land owned by Orange County Parks: 338 trees were infested with GSOB, three of which were newly found in Gypsum Canyon. Eight trees with high levels of infestation were removed, including one in Gypsum Canyon. A total of 2,500 trees in both canyons were sprayed with carbaryl insecticide. Overall, the insecticide applications were effective, as treated trees have a low

number of new adult beetle emergence holes each year. Additionally, a dead tree showing signs of infestation was found in upper Fremont Canyon, although no larvae were found. Orange County Fire Authority personnel cut the tree down and tarped the wood in place.

On the Trabuco Ranger District, between and within Falcon and Blue Jay Campgrounds, carbaryl insecticide was applied to 594 uninfested and lightly-infested large-diameter coast live oak trees (Cleveland National Forest, El Cariso to Long Canyon Goldspotted Oak Borer Management Project).

California black oak tree with bark removed to expose goldspotted oak borer larval feeding galleries. This was the first GSOB-infested tree identified in the Big Bear Lake area (San Bernardino County). Photo by: S. Hishinuma, USFS

First California black oak found to be infested by goldspotted oak borer in Oak Glen, San Bernardino County.
Photo by: K. Corella, CALFIRE

Riverside County

In August 2019, a new GSOB infestation was found on coast live oaks (*Quercus agrifolia*) along Hagador Canyon Trail on the northeast side of the Trabuco Ranger District (Cleveland National Forest). Four trees were found with light to heavy infestation levels. This new infestation is approximately 7 miles from the established infestation in Weir Canyon (Orange County). Hagador canyon is isolated from other infestations, with no surrounding or connecting stands of susceptible oak trees.

San Bernardino County

In November 2018, GSOB was detected for the first time in the county in Oak Glen, a community east of the city of San Bernardino. For management on private land, the Inland Empire Resource Conservation District contacted homeowners, surveyed trees for GSOB infestation (250 trees over 14 properties), felled and chipped five heavily infested trees, and sprayed 246 oaks with carbaryl insecticide. The Wildlands Conservancy Oak Glen Preserve is a 2,189-acre preserve located in the foothills of the San Bernardino Mountains. The primary tree species is California black oak (*Quercus kelloggii*). At the Oak Glen Preserve, 37 dead or heavily infested California black oaks were felled and the wood chipped on site. A total of 187 large black oaks were injected with systemic insecticides, and 150-250 trees were sprayed with a contact insecticide. In 2019 a GSOB Zone of Infestation was established for this location, as well as for the 2017 infestation on the Trabuco Ranger District (Cleveland National Forest) at Blue Jay and Falcon Campgrounds in Orange County.

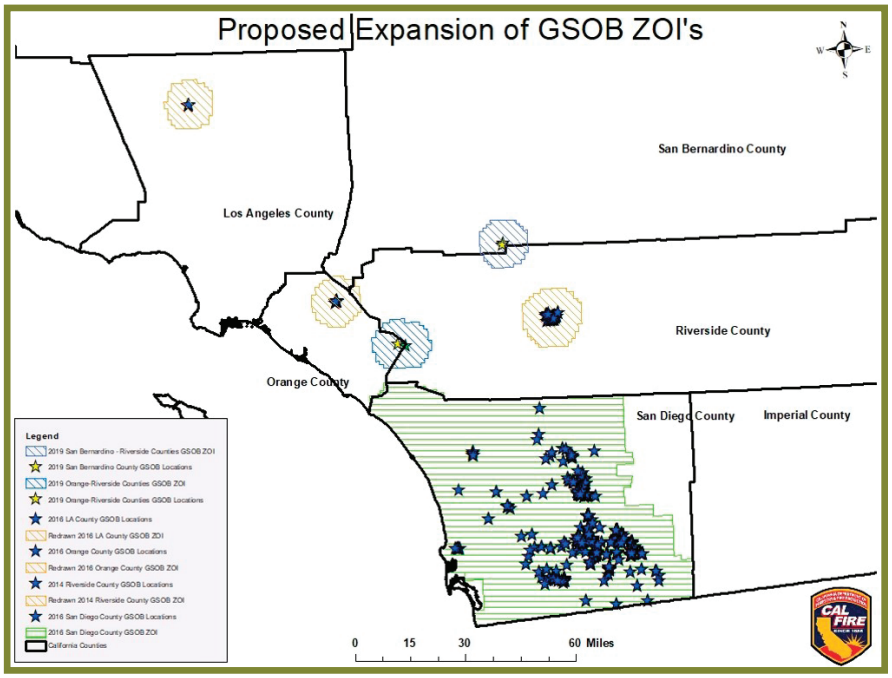
In August 2019, a second infestation of GSOB was identified near Big Bear Lake within the communities of Sugarloaf and Moonridge. Two recently killed multi-stem California black oak trees with active GSOB infestations were found by a San Bernardino County Fire Hazard Officer. CALFIRE personnel felled, debarked and chipped the bark of the infested trees.

San Diego County

For the first time, GSOB was discovered in coast live oak along Escondido Creek in the 900-acre conservation preserve owned by the Escondido Creek Conservancy (San Diego County). Small pockets of 3-8 infested trees were found along the creek. Two of the coast live oak trees were heavily infested.

The Cleveland National Forest completed its third year of preventive carbaryl treatments at three developed recreation and administrative sites with known GSOB infestations. In total, 275 coast live oak trees were treated at the Oak Grove Campground and Fire Station, Pine Hills Fire Station, and Inaja Memorial Picnic Area.

The La Jolla Band of Luiseño Indians detected GSOB in the La Jolla Indian Campground. The campground is a 120-acre property, and many coast live oaks are severely impacted by GSOB. An estimated 100 trees are infested, and 76 trees have been killed.



Goldspotted oak borer, Zone of Infestation (ZOI). Map by: K. Corella, CALFIRE

Invasive Shot Hole Borers ((ISHB) *Euwallacea* spp.) and associated **Fusarium Dieback** (*Fusarium* sp.)

In 2018, the California Legislature passed, and the Governor approved AB 2470 – Invasive Species Council of California (Grayson), which authorized the development of a plan for the cure or suppression of diseases associated with the spread of Invasive Shot Hole Borers (ISHB), including but not limited to the Polyphagous and Kuroshio shot hole borers. It allocated $5 million for the execution of the Invasive Shot Hole Borer plan. In 2019 California Assembly Member Lorena Gonzalez (San Diego) secured $5 million toward CALFIRE's efforts to eradicate ISHBs. The funds were allocated to CALFIRE with language directing the development of "Incident Action Plans" to immediately deploy activities that suppress ISHBs and associated diseases.

Under the coordination of the California Invasive Species Advisory Committee (CISAC), a statewide initiative has been developed to control and manage the emergent pest-disease complex. Through a public consensus-building process, CISAC determined priorities for the appropriation of the $5 million awarded by the State in 2018 to effectively control the pest complex and prevent economic losses and further damage to landscapes. Lead researchers in the field, land managers, and regulators worked collaboratively and strategically to design and implement a cohesive action plan to support the development of essential components of an evolving essential integrated pest management program. The plan outlines the work of four CISAC subcommittees: 1) Research and Technology; 2) Survey, Detection and Rapid Response; 3) Greenwaste and Firewood as Pathways; and 4) Outreach and Education. Because of its significant impacts, rapid expansion in southern California and the potential for widespread impacts to agriculture, the nursery industry, urban landscapes, and riparian communities in southern California and beyond, it was deemed imperative to develop and provide clear and appropriate management information to first responders at local, state and federal levels.

Polyphagous shot hole borer (PSHB) is established in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties. Kuroshio shot hole borer (KSHB) is established in Los Angeles, Orange, Santa Barbara, San Diego, and Riverside Counties. No infestations have been found in San Luis Obispo County, and no further trap finds have been found since one KSHB beetle was detected in a trap there in 2016.

Los Angeles County

Three new infestations were found in the Santa Clara River corridor within the City of Santa Clarita.

San Bernardino County

Polyphagous shot hole borer was identified in the City of Loma Linda within San Timoteo Canyon, the third recorded location in the county. The previous two locations were confirmed in Chino and Ontario in 2013.

Orange County

Orange County continued to have high ISHB infestation pressure and impacts in urban areas and in the wildland-urban interface. University of California Cooperative Extension (UCCE) repeated surveys of turf parks and wilderness areas in Orange County Parks. In 2019, 239 ISHB-infested trees were removed with an estimated loss of value at over $1 million. In addition, 1,206 trees were treated using various management techniques based on host species, location, and infestation level. From 2013-2019, a total of 3,922 ISHB-infested trees have been removed Orange County parks.

In August and September 2019, Irvine Ranch Conservancy staff surveyed trees for ISHB throughout open space owned by the City of Irvine. In Bommer Canyon, a total of 453 trees were surveyed, and 25 arroyo willows (*Salix lasiolepis*), 2 Goodding's black willows (*Salix gooddingii*), and 13 western sycamores (*Platanus racemosa*) were found to be infested. In Shady Canyon, a total of 85 trees were surveyed, and 8 western sycamores were detected as infested. At Quail Hill, a total of 73 trees were surveyed, and 7 arroyo willows, 1 red willow (*Salix laevigata*), and 15 western sycamores were observed to be infested. None of the infested trees met the criteria for removal or treatment as amplifier trees (>50 holes).

San Diego County

An ISHB was found in a baited funnel trap near the La Jolla Indian Campground along the San Luis Rey River (La Jolla Band of Luiseño Indians Reservation). The Cleveland National Forest continues to maintain a trapping network, placing baited traps within high-risk riparian areas on all districts. No additional infestations in riparian areas have been found this year.

ISHBs were detected at Camp Pendleton in Pilgrim Creek at the southeast border of the Marine Corps Base. The area affected is at least 58 acres of riparian forest. The host trees are Goodding's black willow (*Salix gooddingii*) and California sycamore (*Platanus racemosa*).

Santa Barbara County

Monitoring continues via traps at established sites near past finds in Montecito and Mission Canyon.

Ventura County

In December 2018, a new infestation of PSHB was identified in Meiners Oak, located in the west Ojai Valley. The infested area is in wildland-urban interface adjacent to conservancy and National Forest lands. A heavily infested box elder (*Acer negundo*) was identified and removed. Western sycamore (*Platanus racemosa*), Fremont cottonwood (*Populus fremontii*), willow spp. (*Salix* spp.) and valley oaks (*Quercus lobata*) were attacked at various levels. The current known area of infestation is 5 to 10 acres.

In the Hedrick Ranch Nature Area in Santa Paula, PSHB-attacked areas have increased since the initial discovery in 2016 (total acreage is 3,500). Based on data from nine 30-meter (radius) circular plots, the infestation rates are increasing slightly, and some areas are showing signs of recovery. A total of 21 Arroyo willow died over the past year.

Xyleborus monographus, first confirmed infestation in North America

Xyleborus monographus was found infesting valley oaks (*Quercus lobata*) in late fall of 2019 southeast of Calistoga (Napa County). This is the first confirmed infestation by this ambrosia beetle in North America. The beetle is native to Europe where it infests oaks. Work is ongoing to delimit this new infestation in California and identify its fungal associates. A single *X. monographus* beetle was caught in a trap in Oregon in 2018, which was the first of that species found in North America, but no infestations have been found in Oregon.

Native Diseases

Heterobasidion Root Disease

(*Heterobasidion occidentale*)

A large, advanced root disease pocket was observed in a white fir (*Abies concolor*) stand on the Lassen National Forest near Domingo Springs (Plumas County). Approximately 20 acres were heavily impacted with both older and more recent mortality, including blowdown of live trees. Conks and decay patterns confirmed the presence of *Heterobasidion occidentale*.

White fir stand heavily impacted by Heterobasidion root disease, Lassen NF. Photo by: D. Cluck, USFS

Numerous small (0.5-2 acre) root disease centers in mature western hemlock (*Tsuga heterophylla*) were observed in Jedediah Smith State Park, along the Mill Creek drainage near Howland Hill Road in Del Norte County. Many of the dead trees still retained brown needles, indicating recent and relatively synchronous death, although dead trees in all stages of deterioration were present. Fruiting bodies of both *Heterobasidion occidentale* and *Pseudoinonotus dryadeus* were observed at the base of several of the dead trees, and witches' brooms caused by *Arceuthobium tsugense* ssp. *tsugense* (western hemlock dwarf mistletoe) were present in most tree crowns. *Laetiporus conifericola* (sulfur shelf) was also found on dead western hemlock in the area.

Black stain root disease center along Friday Ridge Road, Six Rivers NF. Photo by: C. Lee, CALFIRE

Black Stain Root Disease (*Leptographium wageneri*)

Douglas-firs (*Pseudotsuga menziesii*) declining from black stain root disease (caused by *Leptographium wageneri* var. *pseudotsugae*) were observed in the greater Highway 299 corridor in central Humboldt County. Individual declining trees (all between 8-12 inches DBH) were observed on Friday Ridge Road, Stover Road, and Snow Camp Road, and a black stain root disease center containing approximately 10 trees of 25-40 inches DBH, in all stages of decline and death, was also observed along Friday Ridge Road. All the small declining trees had distress cone crops. One tree exhibited the black stain fungus and a flatheaded fir borer (*Phaenops drummondi*) larva.

Ponderosa pine dieback, Santa Cruz County. Photo by: K. Corella, CALFIRE

Ponderosa (*Pinus ponderosa*) and Jeffrey pine (*P. jeffreyi*) wood samples taken from ten black-stained trees in three locations in northeast California were analyzed at USDA Forest Service Research labs in Corvallis, Oregon and Moscow, Idaho, to learn more about the genetic variability of *L. wageneri*. Collections came from three ponderosa pines in Plumas County just southwest of Lake Almanor near Prattville; three ponderosa pines in Modoc County northeast of Adin near Roney Flats; and four Jeffrey pines in Lassen County in a Heart Rock Black Stain Study plot. Results are pending.

Ponderosa pines (*P. ponderosa*) were significantly affected by black stain root disease in Felton (Santa Cruz County). This small one-acre stand had approximately 40% of the large trees affected by the pathogen. The site appeared to be abnormally dry and hot with sandy soil.

A small pocket (~1/2 acre) of black stain root disease in Douglas-fir (*Pseudotsuga menziesii*) was found after a timber harvest on private land near Lake Almanor (Plumas County). Approximately 15 infected trees made up the root disease center, and all were removed. Adjacent areas supported mixed-conifer forest with very few Douglas-fir. Black stain root disease is not common in the area.

Surveys for black stain root disease on bristlecone pine (*Pinus longaeva*) and singleleaf pinyon (*P. monophylla*) at high elevations near the Methuselah Trail in the Ancient Bristlecone Pine Forest (Inyo National Forest) found very few trees impacted by the

disease. Observers noted that the root disease pockets expand at a very slow rate in these high elevations. The first reports of *L. wageneri* in bristlecones were in 2006, and one root disease pocket has subsequently been observed. During the following years, this pocket expanded by only two trees. While conducting surveys along the Methuselah Trail, a second root disease pocket was detected, and the fungus was isolated from a plug taken from the trees. Originally, the pathogen was suspected to be new to the bristlecone pine forests; however, it is possible that it has always been amongst the trees but extremely slow to kill any hosts. Black stain root disease also expands at a very slow rate in high elevation (9,000+ foot elevation) pinyon pine forests.

Black stain on ponderosa pine in Santa Cruz County. Photo by: K. Corella, CALFIRE

Miscellaneous Root Rots, various fungi

Four large mature redwoods (*Sequoia sempervirens*) around 40-80 inches DBH at Redwood Park in Arcata (Humboldt County) died after a nearby water line break submerged their roots for several weeks. The immediate causes of death were *Phloeosinus sequoiae* (redwood bark beetle), the entry holes and galleries of which could be seen up the trunks for dozens of feet; the root pathogen *Ilyonectria europaea* (= *Cylindrocarpon* sp.), which caused extensive black streaking in many years' growth of xylem at the root crown; and the root pathogens *Elongisporangium undulatum* (= *Pythium undulatum*, = *Phytophthora undulata*) and *Fusarium oxysporum*, which were baited and isolated from small roots.

Ilyonectria spp. were also recovered from two other areas of conifer mortality in north coastal California in 2019. One was a dead totara (*Podocarpus cunninghamii*), a non-native conifer planted in the botanical collection at Humboldt State University. The tree was observed to decline rapidly following a heavy May rainfall that caused extensive flooding on the campus. The isolated fungus was identified as *Ilyonectria capensis*. Another species, *I. robusta*, was isolated from the roots of dying shore pines (*Pinus contorta*) near Lake Earl/Tolowa Dunes State Park (Del Norte County). Shore pine mortality in the area was scattered over a ~150-acre area and was noticed by aerial detection surveyors, who estimated mortality at over 50% of the entire stand. It is unknown whether *I. robusta* was involved in all the mortality, but it is noteworthy that these shore pines grew in a frequently flooded area. *Ilyonectria*, known in its asexual form as *Cylindrocarpon*, is a notorious genus of pathogens of both conifer seedlings and agricultural crops ranging from ginseng to grapevines.

Phytophthora cinnamomi was baited from soil in several locations in the north coast in association with declining or dead trees. It was baited from a 10-acre stand of bishop pine (*Pinus muricata*) in McKerricher State Park (Mendocino County) that has been declining for many years, with only three remaining live trees; from soil in the near-pygmy forest along Mitchell Creek Drive in Fort Bragg (Mendocino County), beneath dying tanoaks (*Notholithocarpus densiflorus*) and chinquapins (*Chrysolepis chrysophylla*); and from a pygmy forest in Jackson State Forest along Little Lake Road near Mendocino (Mendocino County) in association with dying chinquapins and rhododendrons. Dying manzanita (primarily *Arctostaphylos glandulosa*) and chinquapin were observed in small groups on Mount Tamalpais, near the Matt Davis and Hoo-Koo-E-Koo Trails uphill from the Panoramic Highway in Mill Valley (Marin County); the dying shrubs and trees were located near previously surveyed *Phytophthora cinnamomi* disease centers, suggesting that the pathogen is spreading both around and down the slope. Scattered individual declining Douglas-fir (*Pseudotsuga menziesii*) and madrone (*Arbutus menziesii*) trees were also observed near the trails.

Dead and dying Monterey pines associated with *Phytophthora pseudocryptogea* and *Phacidiopycnis tuberivora* near Westport, Mendocino County. Photo by: C. Lee, CALFIRE

Phacidiopycnis tuberivora was isolated from roots of two dying conifers in two different counties: a Monterey pine (*Pinus radiata*) seedling near Westport (Mendocino County) and a dead mature Port-Orford-cedar (*Chamaecyparis lawsoniana*) at East Fort Campground near Willow Creek (Humboldt County). *P. tuberivora* is known primarily as a pathogen of potatoes.

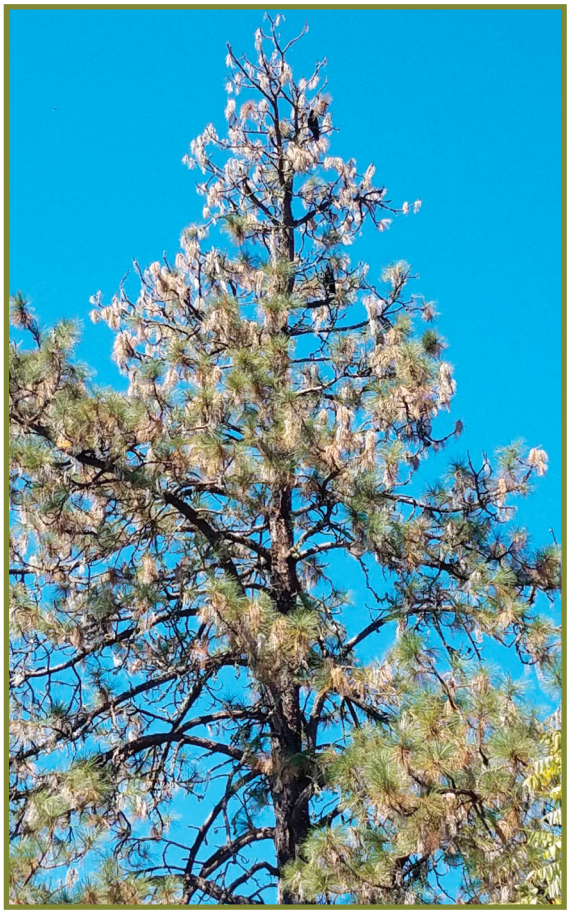
Neofusicoccum on California bay laurel, San Luis Obispo County. Photo by: K. Corella, CALFIRE

Tanoak twig dieback, San Luis Obispo County. Photo by: K. Corella, CALFIRE

Tanoak tree failure, San Luis Obispo County. Photo by: K. Corella, CALFIRE

California Bay Laurel Dieback (*Neofusicoccum nonquaesitum*)
Numerous California bay laurels (*Umbellularia californica*) appeared to be very stressed and dying along Santa Rita Creek and San Simeon - Monterey Creek Roads in San Luis Obispo County. The dieback was seen starting at Highway 1 and continuing along each road until California bay laurels were no longer present. *N. nonquaesitum* was found on the impacted trees.

Tanoak Die-off (*Phytophthora pseudosyringae*)
Dying tanoaks (*Notholithocarpus densiflorus*) were observed in a small isolated area along Santa Rita Creek Road (San Luis Obispo County). The trees in this small stand of tanoaks exhibited oozing cankers, twig dieback, and tree failure at the canker locations. Approximately 10 trees were affected, and *P. pseudosyringae* was isolated from the impacted trees.



Severe *Diplodia pinea* damage on a ponderosa pine in Laytonville, Mendocino County. Photo by: C. Lee, CALFIRE

Diplodia Blight (*Diplodia pinea*)
Branch dieback and tip blight caused by *Diplodia pinea* was epidemic in several northern California locations in 2019. These included thirty miles along Highway 101 from the north tip of Laytonville to the southern end of Willits (Mendocino County). Along this stretch, *D. pinea* apparently infected one-third to one-half of all roadside ponderosa pine (*Pinus ponderosa*). Some trees exhibited diffuse branch tip dieback, while in others, damage was concentrated on large sections of the tree crowns. Some pines had died and others exhibited dieback of the tops of crowns, suggesting bark beetles may have been involved; however, the few accessible dead pines examined showed no evidence of beetle attacks. In late November/early December, disease and mortality in the pine stands at the southern end of this strip intensified. Many more pines exhibited symptoms of Diplodia infection and two groups of 10-12 pines that were newly yellow were most likely attacked by western pine beetle. Other areas in which *D. pinea* infection was more evident than usual in 2019 included Highway 3 between Weaverville and Coffee Creek (Trinity County, on ponderosa pine), Highway 44 west of Shingletown (Shasta County), Highway 299 between Buckhorn Summit and the Lewiston area (Trinity County, on ponderosa pine), Highway 299 between Junction City and Del Loma (Trinity County, on ponderosa pine), and Highway 101 just north of Cloverdale, Sonoma County, on gray pine (*Pinus sabiniana*). Other species of *Diplodia* were recovered from other pine species throughout the north coast, including

Dead ponderosa pine trees, caused by western pine beetle in an area of heavy *Diplodia pinea* infestation near Willits, Mendocino County. Photo by: C. Lee, CALFIRE

D. mutila along with *Pseudips mexicanus* (a bark beetle) on shore pine (*Pinus contorta*) in Arcata (Humboldt County) and *D. scrobiculata* on shore pine north of Lake Earl (Del Norte County).

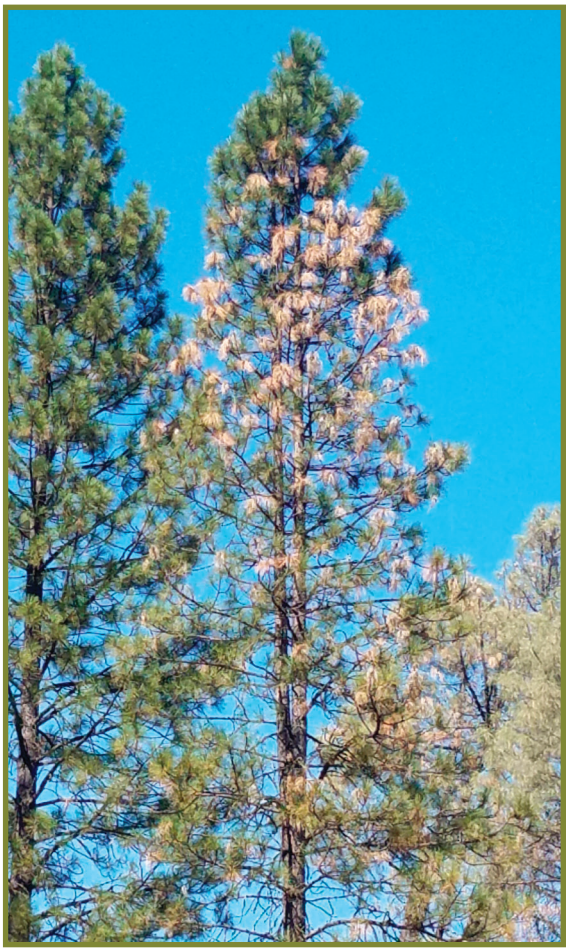
Stands of ponderosa pine (*Pinus ponderosa*) along Highway 49 in Nevada County (Nevada City to Downieville) continued to exhibit severe Diplodia blight symptoms. Trees in the area have been symptomatic for at least twenty years but continue to survive. Interestingly, during the recent western pine beetle epidemic in the area, longtime Diplodia blight symptomatic trees survived while neighboring trees without symptoms were often killed.

Phytophthora Canker (*Phytophthora* sp.)
Ten lemonade sumac (*Rhus integrifolia*) suddenly appeared to wilt from the base of the trunk, showing necrosis and cankering that affected their vascular systems at the San Elijo Nature Center, San Elijo Lagoon Ecological Reserve (San Diego County). San Elijo Lagoon is a 979-acre reserve that supports native plants adapted to an estuarine environment. A *Phytophthora* species was detected by immunoassay of samples as the cause of this dieback. There are many other lemonade sumac trees in the reserve.

Anthracnose of Dogwood (*Gnomonia* sp.)
Extensive symptoms of anthracnose were observed on dogwoods (*Cornus nuttallii*) in Crestline (San Bernardino County). Most of the trees, on private lands bordering National Forest areas, experienced nearly complete defoliation fostered by foggy and humid weather during April-May 2019.

Botryosphaeria Canker (*Botryosphaeria* sp.)
Various species of willows (predominately *Salix lasiolepis*, and some *S. laevigata*, *S. gooddingii*) on a 5-acre wetland mitigation site on the south side of the Prima Deshecha Landfill (Orange County) exhibited dieback and decline from *Botryosphaeria* sp. Approximately 20% of the trees were affected.

Seiridium Canker (*Seiridium* spp.)
Seiridium spp., cause of cypress canker, was observed on less common hosts in 2019. Near the mouth of the Navarro River (Mendocino County), spores were observed in cankered branch tissue of severely damaged mature redwood (*Sequoia sempervirens*) trees. Some of the trees, which were growing in an area with heavy vehicle traffic and human use, appeared completely top-dead, and others had numerous dead branches. *Phytophthora cactorum* was



Diplodia pinea symptoms on ponderosa pine in Willits, Mendocino County. Photo by: C. Lee, CALFIRE

Phytophthora canker on *Rhus integrifolia* in San Diego County. Photo by: D. Lombardo, County of San Diego Department of Parks and Recreation

also baited from soil at the base of one group of trees that appeared to be dead. However, the redwoods had sustained unsuccessful redwood bark beetle (*Phloeosinus sequoiae*) attacks and subsequently began to produce a new flush of foliage.

Seiridium sp. spores (appearing most like *S. cardinale*) were also recovered from small dying trees and resinous branch cankers on numerous dead and dying Santa Cruz cypress (*Hesperocyparis abramsiana*) in the Bracken Brae population of this rare conifer, near Boulder Creek (Santa Cruz County). The cypress trees were also impacted by an unknown fungus that caused a brown cubical butt rot, sufficiently severe to cause wind-snapped boles in several green trees and to uproot many others.

A group of Santa Cruz cypress with trees in all stages of health and decline, near Boulder Creek, Santa Cruz County. The small red tree has a basal canker caused by *Seridium* sp.
Photo by: C. Lee, CALFIRE

A snapped green Santa Cruz cypress with extensive basal decay near Boulder Creek, Santa Cruz County.
Photo by: C. Lee, CALFIRE

Maple Leaf Scorch, cause unknown

Maple leaf scorch on bigleaf maple (*Acer macrophyllum*) occurred along many of the same highways reported in past years (State Highways 3, 20, 36, 49, 50, 70, 89, 96 and 299, and Interstates 5 and 80). Most of the foliage on up to half the maples along these highways had symptoms of maple leaf scorch. Some of the large maples, with dead tops and recurring heavy scorch symptoms died. A clump of 12 bigleaf maples along Highway 3 north of Hayfork (Trinity County) have experienced maple leaf scorch in half the trees for over a decade. Almost no indications of xylem feeding insects were found on leaves that could be reached from the ground. It seemed unlikely that a lack of soil moisture was causing scorching symptoms since affected and asymptomatic trees were intermixed. It is more likely that a pathogen is causing the reoccurrence of maple leaf scorch, possibly the xylem-plugging bacteria *Xylella fastidiosa*.

Roadside big leaf maples exhibiting maple leaf scorch symptoms. Photo by: W. Woodruff, USFS

Close-up of big leaf maple leaf showing symptoms of maple leaf scorch and insect feeding injury.
Photo by: W. Woodruff, USFS

In some locations, for example along State Highway 3 near Trinity Lake, where bigleaf maple seedlings are growing on the highway fill bank, it is possible that early-season soil drying caused the maple leaf scorch symptoms. At this location, signs of xylem feeding insects were found, so insects may also be contributing to scorching in some locations.

From 2009 through 2016, approximately 350 collections of scorched maple leaves from trees in northern California were analyzed at four university labs for *X. fastidiosa* using ELISA and DNA tests – with inconclusive results. The first year of testing found evidence of *X. fastidiosa* in the leaf petioles. Refined testing in later years did not find evidence of the bacteria in the petioles. The cause of maple leaf scorch is not known despite its occurrence on bigleaf maples in northern California, Oregon, and Washington likely since the 1960s. The disorder could be due to a pathogen, climate change, or both, with xylem-feeding insects involved in some locations. Additional studies are needed to identify the cause or causes of maple leaf scorch.

Marssonina Blight (*Marssonina populi*)
Marssonina blight of aspen (*Populus tremuloides*) was greatly reduced from prior years across northeastern California, with only a few stands noticeably impacted. A stand with higher levels of infection was found at Jones Valley (~10 acres), Tahoe National Forest (Sierra County).

Tar Spot of Maple (*Rhytisma punctatum*)
The majority of leaves of bigleaf maples (*Acer macrophyllum*) along Highway 49 between Downieville and Sierra City (Sierra County) and along 15 miles of Highway 50 east of Pollock Pines (Eldorado County) showed symptoms of *Rhytisma punctatum*. Tar spot fungus is considered an endophyte. *R. punctatum* lives in plants, and it fruits when the leaves senesce. The immature ascospores remain in the tar spots until spring when they mature and are released to infect emerging maple leaves. This fungus does not cause serious damage to maples.

Oak Anthracnose (*Apiognomonia quercina*)
Oak anthracnose caused dieback and premature leaf fall of oak leaves throughout the foothills of the Sierra Nevada Mountain Range. California black oak (*Quercus kelloggii*) appeared to be more severely impacted than other oak species. Ample rain in winter, along with late spring rains, likely promoted anthracnose infection.

Tubakia (*Tubakia* spp.)
Tubakia spp., in most cases probably *T. californica*, was observed causing leaf symptoms and twig dieback on oaks and tanoaks in several areas of northern California, including on mature valley oaks (*Quercus lobata*) also affected by *Xyleborus monographus* and associated fungi in Calistoga (Napa County); on coast live oak (*Q. agrifolia*) seedlings and mature trees in Sebastopol (Sonoma County); and, probably in association with *Diplodia* spp., on numerous tanoaks (*Notholithocarpus densiflorus*) along Highway 101 near Leggett (Mendocino County) and along Highway 299 near Salyer (Humboldt County) and Burnt Ranch (Trinity County).

Elytroderma Needle Blight (*Elytroderma deformans*)
Severe witches' brooming caused by *Elytroderma deformans* was noted in ponderosa pine (*Pinus ponderosa*) along a 2-mile stretch of the west shore of Lake Almanor (Plumas County).

Tar spot on bigleaf maple. Photo by: W. Woodruff, USFS

Close-up of tar spot on bigleaf maple. Photo by: W. Woodruff, USFS

Witches' brooming caused by *Elytroderma deformans* at Lake Almanor, Plumas County. Photo by: C. Lee, CALFIRE

Mountain Hemlock Dwarf Mistletoe (*Arceuthobium tsugene* subsp. *mertensianae*)
Mountain hemlock dwarf mistletoe was recorded for the first time on mountain hemlock (*Tsuga mertensiana*) in Yosemite National Park (Mariposa County). Recent reports of this mistletoe attacking sugar pine (*Pinus lambertiana*) around Crater Lake, Oregon, are prompting further surveys for this mistletoe on sugar pine in California in the future.

Exotic Diseases

White Pine Blister Rust
(*Cronartium ribicola*)
A survey by National Park Service personnel in Yosemite, Sequoia, and Kings Canyon National Parks (Sierra Nevada Mountain Range) found no white pine blister rust infection on foxtail pine (*Pinus balfouriana*) and only low infection severity (less than 1%) of whitebark pine (*P. albicaulis*). In Yosemite National Park, rust infections were observed within one plot (a total of 12 trees), while in Kings Canyon National Park fewer trees were infected but were more widely scattered across multiple plots.

Bishop pine mortality caused by pitch canker at Point Reyes, Marin County. Photo by: C. Lee, CALFIRE

Pitch Canker (*Fusarium circinatum*)
Pitch canker infections continued to cause severe branch flagging and scattered whole-tree mortality in bishop pine (*Pinus muricata*) from Point Reyes (Marin County) north to Iverson Road (Mendocino County). Although spread of the causal pathogen (*Fusarium circinatum*) north of this point is suspected, confirmatory sampling has not been completed.

Port-Orford-cedar Root Disease (*Phytophthora lateralis*)
Scattered individual dead Port-Orford-cedar trees (*Chamaecyparis lawsoniana*) were observed along South Fork Road (Del Norte County), along Terwer Valley Road (Humboldt County), and in other parts of the lower Klamath River drainage.

Sudden Oak Death (*Phytophthora ramorum*)
Outbreaks of sudden oak death, caused by *Phytophthora ramorum*, continued to cause high levels of mortality throughout the pathogen's known distribution in California coastal areas in 2019. Estimated sudden oak death-caused mortality incidence (observed through aerial survey) decreased only slightly from 2018 levels in both the north and central coasts. Both levels are still large increases from 2017.

In the north coast, the pathogen was detected for the first time in trees in Del Norte County, in Jedediah Smith State Park near Mill Creek, a tributary to the main stem Smith River where a stream bait had yielded a PCR positive in 2012. At that time, the pathogen was never isolated from the stream bait, and the stream didn't subsequently test positive. The 2019 detection does not change the quarantine boundary since the samples were not collected by a regulatory official. Further sampling is planned for the area.

In Humboldt County, the pathogen caused increasing levels of mortality along the Redwood Creek corridor. Notable areas of California bay laurel (*Umbellularia californica*) and tanoak (*Notholithocarpus densiflorus*) infection include the Tall Trees Grove in Redwood National Park and Stover Road, upstream from the Park. Increased levels of mortality were also noted in the Mattole River

Dead tanoak adjacent to tree in which *Phytophthora ramorum* was detected in July 2019 in Jedediah Smith State Park, Del Norte County. Photo by: C. Lee, CALFIRE

watershed in southwestern Humboldt County. In Mendocino County, areas of increased mortality were observed in the Inglenook area north of Fort Bragg, as well as along the Highway 128 corridor east of Boonville in the Con Creek and Indian Creek watersheds. In eastern Sonoma County, new mortality was observed along Highway 29 north of Calistoga, extending into the marginal Lake County *P. ramorum* infestation. The most intensive concentration of tanoak mortality, however, remained western Sonoma County, with some local areas of at least 70-90% tanoak mortality around Fort Ross and Timber Cove.

In the San Francisco Bay Area, sudden oak death intensified in several localities. These included Marin County (San Rafael, Woodacre, Larkspur, Mount Tamalpais, Marin City and Inverness), the western part of the East Bay (especially San Leandro, El Cerrito, Kensington, and Berkeley), and parts of the South Bay (Burlingame Hills, northern Woodside, Emerald Hills, Palomar Park, and Portola Valley). Additionally, mortality was observed in new or expanded locations in Santa Clara and Santa Cruz Counties, including both sides of the ridge between Watsonville and Morgan Hill (Highway 152).

Evidence of heavy ambrosia beetle attacks on a tree infected by *Phytophthora ramorum* in the Tall Trees Grove, Redwood National Park, Humboldt County.
Photo by: C. Lee, CALFIRE

Monterey County also exhibited intensified tanoak mortality in 2019. The Big Creek, Mill Creek, Plaskett Creek, and Willow Creek watersheds showed levels of tree death comparable to those of the early 2000s, and increased coast live oak mortality was also noted. Farther south, *P. ramorum* was recovered in the Santa Rita and San Simeon Creek drainages in San Luis Obispo County. Although these drainages are infested, San Luis Obispo County does not fall under quarantine because no terrestrial infections have been detected by the California Department of Food and Agriculture or County Agricultural officials. San Carpoforo Creek, very close to the border between Monterey and San Luis Obispo Counties, was previously found positive in 2012, 2017, and 2018. Santa Rita and San Simeon Creeks were surveyed, with vegetation samples being taken at ¼-mile intervals for five miles along each creek, but the pathogen was not recovered from the plant samples.

European Leafy Mistletoe (*Viscum album*)

In 2019 Sonoma County was surveyed for the spread of *Viscum album* (European leafy mistletoe), the only non-native mistletoe species known to be established in North America. The mistletoe was introduced to Santa Rosa around the turn of the twentieth century, and previous surveys were conducted in 1971, 1986, and 1991. The current survey observed infected trees up to 15.3 miles from the point of introduction, double the farthest distance reported in 1991. The estimated area encompassed by mistletoe-infected hosts increased greatly, from 71 square miles in 1991 to 234 square miles in 2019. *V. album* appears to be limited by available habitat and hosts but within the survey area was intensifying, concentrated in urban and semi-urban yards, streets, and farms. However, riparian areas may represent a significant pool of native hosts. The mistletoe had spread south to Penngrove and Petaluma and north to Windsor. There had been little spread to the east and west due to native upland forests that have no suitable hosts. The survey also noted significant infestations of the native leafy mistletoe *Phoradendron villosum* in planted oak hosts, particularly pin oak (*Quercus palustris*), in urban areas around Sonoma County, and another native leafy mistletoe (*Phoradendron macrophyllum*) in native and non-native riparian hosts including red alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), poplar (*Populus* spp.), and black locust (*Robinia pseudoacacia*).

Drought

Although drought conditions ended in California a couple of years ago, some species of trees continue to be impacted. The drought was the worst in California's recorded history, and many tree species experienced high levels of mortality, dieback or stress. This resulted in successful attacks by bark beetles or other insects. Many trees also lost fine feeder roots necessary for water uptake. Two species, blue oak (*Quercus douglasii*) and incense cedar (*Calocedrus decurrens*), experienced scattered mortality throughout California in 2019. No insects or diseases were detected at these sites, but many were drier than areas not experiencing mortality. The suspected cause was continued stress related to drought.

Coastal Pine Decline

Coastal pine decline was observed to intensify in many areas of the north coast in 2019 (coastal areas of Sonoma County north to Del Norte County). Tree species affected included shore pine (*Pinus contorta*), bishop pine (*P. muricata*), and Monterey pine (*P. radiata*). Damage patterns varied from area to area. In some sites, the pattern of decline featured individual branch dieback that progressed seemingly randomly throughout the crown of the tree. In others, the tree crown faded all at once. Areas of note in 2019 included ~150 acres of declining shore pine north of Lake Earl in Del Norte County; ~10 acres of declining and dying Monterey pine along Highway 101 near Loleta in Humboldt County; ~5-10 acres of quickly spreading severe mortality in Monterey pine near Westport in Mendocino County; and severe decline visible to aerial surveyors in the Timber Cove and Fort Ross areas of the Sonoma County coast. Several tree pests have been implicated in the decline. The activity of some of them may have been increased by changes in climate (e.g., increased minimum winter temperatures), specific weather events (e.g., warm rain in May 2019) or lack of fire required for regeneration. Some diseases have also been involved, including native pests *Onnia* sp. (cause of a white root and butt rot), *Phaeolus schweinitzii* (brown cubical butt rot), *Armillaria* sp., *Diplodia scrobiculata*, and *Endocronartium harknessii* (western gall rust), while non-native pests that have intensified the problem in many areas include *Phytophthora cinnamomi*, *Phytophthora pseudocryptogea*, and *Fusarium circinatum* (the cause of pitch canker).

Dying shore pine near Lake Earl, Del Norte County. Photo by: C. Lee, CALFIRE

Incense cedar dieback near Weaverville, Trinity County. Photo by: C. Lee, CALFIRE

Unusual levels of incense cedar mortality were noted in various parts of northern California. No pattern was apparent in the mortality: trees of all sizes and growing on a variety of site types were affected. In many trees, mortality began as top dieback and progressed down the tree. In other trees, scattered branch dieback was more evident, sometimes followed by whole-tree mortality and sometimes not. No insect activity was apparent. A species of *Cytospora* was recovered from killed branches at one site near Weaverville (Trinity County), but not at others. *Cytospora* spp. are known as invaders of stressed and wounded tissues. An unknown abiotic stress is suspected as the inciting event for this unexplained dieback.

Black Bears (*Ursus americanus*)
Bear-caused damage on coast redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*) continued to be notable in 2019 in Del Norte, Humboldt, and Mendocino Counties, with aerial surveyors noting bear-caused damage almost as far south as Gualala in southern Mendocino County.

Western Gray Squirrel (*Sciurus griseus*)
Fresh top kill of coast redwood (*Sequoia sempervirens*), probably caused by squirrels, was conspicuous in several locations in Humboldt County in 2019, including Arcata and along Highway 101 near Redcrest and Myers Flat.

Bear-caused damage to young Douglas-fir on a coastal property north of Fort Bragg, Mendocino County. Photo by: C. Lee, CALFIRE

Programmatic Update:

Weed Management Area (WMA) funding was restored in 2019 with nearly $2 million in state funding, issued in 30 grants to counties. The California Dept. of Food & Agriculture (CDFA) had managed the Weed Management Area (WMA) program from 2000 to 2010, when the department eliminated the program due to a budget shortfall. Additionally, as proposed in the 2018 Invasives Species Summit, 2018 legislation codified the interagency Invasive Species Council of California.

WMAs bring together all local stakeholders concerned with controlling invasive plants. These grants are funding on-the-ground management as well as survey and mapping. A portion of the $2 million funded the California Association of Nurseries and Garden Centers and PlantRight (plantright.org) which works to prevent introductions of invasive plants through horticulture.

Also in the state's 2019/2020 budget, CDFA received $3 million to be renewed annually. This funding will allow CDFA to contribute to implementation of the state's Biodiversity Initiative, adopted in late 2018 via an executive order from then-Governor Jerry Brown. This funds $1.8 million in additional grants to WMAs in 2020 as well as $600,000 in grants for research, prioritization, prevention and outreach. The remainder of the funds support CDFA's administrative costs to run the program.

Resources:

The US Fish & Wildlife worked with the California Invasive Plant Council (Cal-IPC) to produce a "Land Manager's Guide to Developing an Invasive Plant Management Plan." With support from the Forest Service, Pacific Southwest Region, Cal-IPC also produced a flyer and slide deck to educate contractors working in tree mortality zones about best practices for avoiding the spread of invasive plants. Finally, Cal-IPC worked with funding from the National Fish & Wildlife Foundation to produce a best practices guide for avoiding invasive plant spread when restoring Sierran meadows.

New Invasive Plants

Eight plant species were identified in 2019 by CDFA and the California Invasive Plant Council (Cal-IPC) as potential threats in the state – *Carrichtera annua*, *Centaurea diluta*, *Euphorbia helioscopia*, *Fallopia* spp., *Pilosella aurantiaca*, *Pistia stratiotes*, *Rytidosperma* spp., and *Senecio angustifolius* – and one, *Heracleum mantegassianum*, that has not yet entered the state.

Of the species highlighted, *Senecio angustifolius* was the only new species to the state in 2019. It had been incorrectly identified as *S. leptophyllus* and, earlier, as *S. quadridentatus*. This species is a fine-textured shrub from South Africa that appears to be highly capable of spreading into undisturbed shrubland and dry alluvial systems. Currently it occurs in San Diego and Orange Counties. A similar non-native species, *S. quadridentatus*, has been observed in Santa Barbara County.

Fallopia japonica (Japanese knotweed), a well-known weed worldwide, was highlighted due to its local expansion in several areas of the state, its potential for high impact on riparian systems, and the large investment needed to effectively remove it once established. It is a CDFA A-rated weed and Cal-IPC Moderate-Alert. Hybrids and close relatives of this species (*F. x bohemica*, *F. sachalinensis*) exhibit similar characteristics.

Also of concern, orange hawkweed (*Pilosella aurantiaca*, syn. *Hieracium aurantiacum*), a stoloniferous weed, occurs in forest meadows and along roadsides. It has spread extensively across Washington and Oregon but is very limited in distribution in California, though probably under-reported. *Pilosella* expansion appears to be favored by wildfire, and its apomictic (asexual) mode of seed production means, under favorable conditions, a single plant can form a new population. It has a CDFA B rating and is currently pending assessment by Cal-IPC.

Senecio angustifolius. Photo by: R. Vanderhoff, California Native Plant Society, Orange County Chapter

Pilosella aurantiaca [syn. Hieracium aurantiacum]. Photo: M. Shephard, USFS, Bugwood.org

In 2019, scientific publications concerning California forest pests and wildland conditions included:

Aram, K. and Rizzo, D.M. 2019. *Phytophthora ramorum* and *Phytophthora gonapodyides* differently colonize and contribute to the decomposition of green and senesced *Umbellularia californica* leaves in a simulated stream environment. Forests. 10(5): 434.

Axelson, J.; Battles, J.; Bulaon, B.; Cluck, D. and others. 2019. The California Tree Mortality Data Collection Network - Enhanced communication and collaboration among scientists and stakeholders. California Agriculture. 73(2): 55-62.

Carrillo, J.D.; Mayorquin, J.S.; Stajich, J.E. and Eskalen, A. 2019. Probe-based multiplex real-time PCR as a diagnostic tool to distinguish distinct fungal symbionts associated with *Euwallacea kuroshio* and *E. whitfordiodendrus* in California. Plant Disease. doi.org/10.1094/PDIS-01-19-0201-RE.

Carrillo, J.D.; Rugman-Jones, PF.; Husein, D.; Stajich, J.E.; Kasson, M.T.; Carrillo, D.; Stouthamer, R. and Eskalen, A. 2019. Members of the *Euwallacea fornicatus* species complex exhibit promiscuous mutualism with ambrosia fungi in Taiwan. Fungal Genetics and Biology. Volume 133, December doi.org/10.1016/j.fgb.2019.103269.

Cobb, R.C.; Ross, N.; Hayden, K.J.; Eyre, C.A.; Dodd, R.S.; Frankel, S.J.; Garbelotto, M. and Rizzo, D.M. 2019. Promise and pitfalls of endemic resistance for cultural resources threatened by *Phytophthora ramorum*. Phytopathology. 109(5): 760-769.

Coleman, T.W.; Poloni, A.L.; Chen, Y.; Thu, P.Q. and others. 2019. Hardwood injury and mortality associated with two shot hole borers, *Euwallacea* spp., in the invaded region of southern California, USA, and the native region of Southeast Asia. Annals of Forest Science. 76(3): 61.

Conrad, A.O.; McPherson, B.A.; Lopez-Nicora, H.D.; D'Amico, K.M.; Wood, D.L. and Bonello, P. 2019. Disease incidence and spatial distribution of host resistance in a coast live oak/sudden oak death pathosystem. Forest Ecology and Management. 433: 618-624.

Cottrell, S.; Mattor, K.M.; Morris, J.L.; Fettig, C.J. and others. 2019. Adaptive capacity in social–ecological systems: a framework for addressing bark beetle disturbances in natural resource management. Sustainability Science. 2019. https://doi.org/10.1007/s11625-019-00736-2

Dale, A.L.; Feau, N.; Everhart, S.E.; Dhillon, B.; Wong, B.; Sheppard, J.; Bilodeau, G.J.; Brar, A.; Tabima, J.F.; Shen, D.; Brasier, C.M.; Tyler, B.M.; Grünwald, N.J. and Hamelin R.C. 2019. Mitotic recombination and rapid genome evolution in the invasive forest pathogen *Phytophthora ramorum*. mBio. 10:e02452-18. doi.org/10.1128/mBio.02452-18.

Dillon, W.W. and Meentemeyer, R.K. 2019. Direct and indirect effects of forest microclimate on pathogen spillover. Ecology. 100(5): e02686.

Dimson, M.; Lynch, S.C. and Gillespie, T.W. 2019. Using biased sampling data to model the distribution of invasive shot-hole borers in California. Biological Invasions. 21(8): 2693-2712.

Feau, N.; Ojeda, D.I.; Beauseigle, S.; Bilodeau, G.J. and others. 2019. Improved detection and identification of the sudden oak death pathogen *Phytophthora ramorum* and the Port-Orford-cedar root pathogen *Phytophthora lateralis*. Plant Pathology. 68(5): 878-888.

Fettig, C.J., Mortenson, L.A., Bulaon, B.M. and Foulk, P.B. 2019. Tree mortality following drought in the central and southern Sierra Nevada, California, US. Forest Ecology and Management. 432: 164-178.

Garbelotto, Matteo; Frankel, Susan J.; Scanu, Bruno. 2018. Soil- and waterborne Phytophthora species linked to recent outbreaks in Northern California restoration sites. California Agriculture. 72(4): 208-216.

Gaydos, D.A.; Petrasova, A.; Cobb, R.C. and Meentemeyer, R.K. 2019. Forecasting and control of emerging infectious forest disease through participatory modelling. Philosophical Transactions R. Soc. B. 374(1776): 20180283. doi.org/10.1098/rstb.2018.0283.

Grünwald, N.J.; LeBoldus, J.M. and Hamelin, R.C. 2019. Ecology and evolution of the sudden oak death pathogen *Phytophthora ramorum*. Annual Review of Phytopathology. 57: 301-321.

Hansen, E.; Reeser, P.; Sutton, W.; Kanaskie, A.; Navarro, S. and Goheen, E.M. 2019. Efficacy of local eradication treatments against the sudden oak death epidemic in Oregon tanoak forests. Forest Pathology. doi.org/10.1111/efp.12530.

He, Y.; Chen, G.; Potter, C. and Meentemeyer, R.K. 2019. Integrating multi-sensor remote sensing and species distribution modeling to map the spread of emerging forest disease and tree mortality. Remote Sensing of Environment. 231: DOI: 10.1016/j.rse.2019.111238

Kalantarzadeh, M.; Mulholland, D.A.; De Leij, F.A.A.M. and Webber, J.F. 2019. Induced antimicrobial activity in heat-treated woodchips inhibits the activity of the invasive plant pathogen *Phytophthora ramorum*. Plant Pathology. 68(5): 889-900.

Keriö, S.; Daniels, H.A.; Gomez-Gollego, M.; Tabima, J.F.; Lenz, R.R.; Søndreli, K.L.; Grünwald, N.J.; Williams, N.; Mcdougal, R. and Leboldus, J.M. 2019. From genomes to forest management – tackling invasive *Phytophthora* species in the era of genomics. Canadian Journal of Plant Pathology. DOI: 10.1080/07060661.2019.1626910.

Larvie, K.; Moody, T.; Axelson, J.; Fettig, C. and Cafferata, P. 2019. Synthesis of research into the long-term outlook for Sierra Nevada forests following the current bark beetle epidemic. California Forestry Note. No. 122. 27 pages.

Lee, C.A., Frankel, S.J., Rizzo, D.M. 2019. Phytophthora ramorum and congenerics: global threats to oaks. International Oaks 30: 349-356.

Lee, C.A., Voelker, S., Angwin, P.A. 2019. Investigating causes of bishop pine decline on California's north coast. In Potter, K.M., Conkling, B.L., eds. Forest Health Monitoring: National Status, Trends, and Analysis 2018. Asheville, NC: USDA Forest Service. pp. 145-153.

Malar, C,M.; Yuzon, J.D.; Das, S.; Das, A.; Panda, A.; Ghosh, S.; Tyler, B.M.; Kasuga, T. and Tripathy, S. 2019. Haplotype-phased genome assembly of virulent *Phythophthora ramorum* isolate ND886 facilitated by long-read sequencing reveals effector polymorphisms and copy number variation. Molecular Plant-Microbe Interactions. doi.org/10.1094/MPMI-08-18-0222-R.

Mastin, A.J.; van den Bosch, F.; van den Berg, F. and Parnell, S.R. 2019. Quantifying the hidden costs of imperfect detection for early detection surveillance. Philosophical Transactions of the Royal Society B. 374(1776): 20180261.

Migliorini, D.; Ghelardini, L.; Luchi, N.; Capretti, P.; Onorari, M. and Santini, A. 2019. Temporal patterns of airborne *Phytophthora* spp. in a woody plant nursery area detected using real-time PCR. Aerobiologia. 35(2): 201-214.

Nesmith, J. and L. Mutch. 2019. Whitebark and foxtail pines in the Sierra Nevada – assessing stand structure and condition. Cirmount 13(2): 17-21.

North, M.P.; Stevens, J.T.; Greene, D.F.; Coppoletta, M.; Knapp, E.E. and others. 2019. Tamm Review: Reforestation for resilience in dry western U.S. forests. Forest Ecology and Management. 432: 209–224.

Peterson, E.K.; Larson, E. R. and Parke, J.L. 2019. Film-forming polymers and surfactants reduce infection and sporulation of *Phytophthora ramorum* on Rhododendron. Plant Disease. 103(6): 1148-1155.

Rabaglia, R.J.; Cognato, A.I.; Hoebeke, E.R.; Johnson, C.W. and others. 2019. Early detection and rapid response: a 10-year summary of the USDA Forest Service program of surveillance for non-native bark and ambrosia Beetles. American Entomologist. 65(1): 29–42.

Ray, C.; Cluck, D.R; Wilkerson, R.L.; Siegel, R.B., White, A.M. and others. 2019. Patterns of woodboring beetle activity following fires and bark beetle outbreaks in montane forests of California, USA. Fire Ecology. 15(1): 21.

Redekar, N.R.; Eberhart, J. L. and Parke, J.L. 2019. Diversity of *Phytophthora*, *Pythium*, and *Phytopythium* species in recycled irrigation water in a container nursery. Phytobiomes Journal. 3(1): 31-45.

Restaino, C.; Young, D.J.; Estes, B.; Gross, S.; Wuenschel, A.; Meyer, M. and Safford, H. 2019. Forest structure and climate mediate drought-induced tree mortality in forests of the Sierra Nevada, USA. Ecological Applications. 29(4): e01902.

Seybold, S.J.; Klingeman, W.E., III; Hishinuma, S.M. and others. 2019. Status and impact of walnut twig beetle in urban forest, orchard, and native forest ecosystems. Journal of Forestry. 117: 152–163.

Sillo, F.; Gonthier, P.; Lockman, B.; Kasuga, T. and Garbelotto, M. 2019. Molecular analyses identify hybridization-mediated nuclear evolution in newly discovered fungal hybrids. Ecology and Evolution, 9(11): 6588-6605.

Sims, L.L.; Chee, C.; Bourret, T.; Hunter, S. and Garbelotto, M. 2019. Genetic and phenotypic variation of *Phytophthora crassamura* isolates from California nurseries and restoration sites. Fungal Biology. 123(2): 159-169.

Socorro, M.S.; Osmundson, T.; Almaraz-Sanchez, A.; Croucher, P.J.; Swiecki, T.; Alvarado, D. and Garbelotto, M. 2019. A microsatellite analysis identifies global pathways of movement of *Phytophthora cinnamomi* and the likely sources of wildland infestations in California and Mexico. Phytopathology. doi.org/10.1094/PHYTO-03-19-0102-R.

Søndreli, K.L.; Kanaskie, A.; Keriö, S. and LeBoldus, J.M. 2019. Variation in susceptibility of tanoak to the NA1 and EU1 lineages of *Phytophthora ramorum*, the cause of sudden oak death. Plant Disease. https://doi.org/10.1094/PDIS-04-19-0831-RE.

Stephenson, N.L.; Das, A.J.; Ampersee, N.J.; Bulaon, B.M. and Yee, J.L. 2019. Which trees die during drought? The key role of insect host-tree selection. Journal of Ecology. 107(5): 2383-2401.

Swiecki, T.; Quinn, M.; Sims, L.; Bernhardt, E.; Oliver, L.; Popenuck, T. and Garbelotto, M. 2018. Three new *Phytophthora* detection methods, including training dogs to sniff out the pathogen, prove reliable. California Agriculture. 72(4): 217-225.

Tooley, P.W. and Browning, M. 2019. The effect of leaf wetness on *Phytophthora ramorum* zoospore infection of *Rhododendron* 'Cunningham's White' and *Viburnum tinus*. Plant Disease. 103(7): 1651-1656.

Younis, B.A.; Mahoney, L.; Schweigkofler, W. and Suslow, K. 2019. Inactivation of plant pathogens in irrigation water runoff using a novel UV disinfection system. Eur. J. Plant Pathology. 153(3): 907–914.

The California Forest Pest Council (CFPC), a 501(c)(3) non-profit organization, was founded in 1951 as the California Forest Pest Control Action Council. Membership is open to public and private forest managers, foresters, silviculturists, entomologists, plant pathologists, biologists, and others interested in the protection of California's urban and wildland forests from injury caused by biotic and abiotic agents. The Council's objectives are to establish, maintain, and improve communication among individuals who are concerned with these issues. These objectives are accomplished by:

1. Coordinating the detection, reporting, and compilation of pest injury, primarily from forest insects, diseases, and animal damage.
2. Evaluating pest conditions, primarily those of forest insects, diseases, and animal damage.
3. Making recommendations on pest control to forest managers, protection agencies, and forest landowners.
4. Reviewing policy, legal, and research aspects of forest pest management and submitting recommendations to appropriate authorities.
5. Fostering educational work on forest pests and forest health.

The California Board of Forestry and Fire Protection recognizes the Council as an advisory body in forest health protection, maintenance, and enhancement issues. The Council is a participating member in the Western Forest Pest Committee of the Western Forestry and Conservation Association.

This report was prepared by Forest Health Protection, US Forest Service, Pacific Southwest Region and the California Department of Forestry and Fire Protection with other member organizations of the Council.

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Cover Photo
Western white pine mortality caused by mountain pine beetle, associated with white pine blister rust, Tahoe NF. Photo by: D. Cluck, USFS

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